Nelson Spaulding

JOURNAL *of* FORESTRY

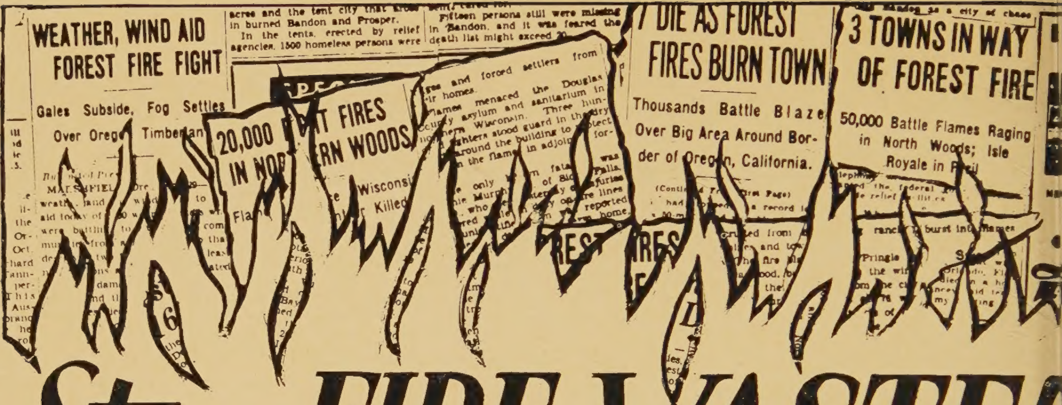
APRIL
1937

Vol. 35 No. 4

SOCIETY OF AMERICAN FORESTERS 1900

Published by the
SOCIETY of AMERICAN FORESTERS

Single Copy Fifty Cents Four Dollars per Year



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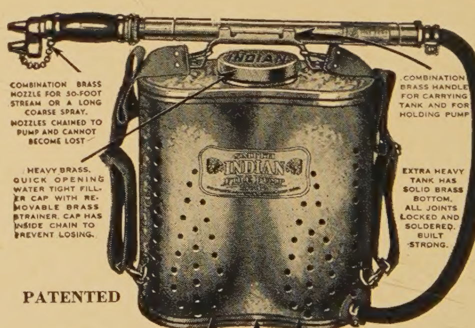

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JOURNAL of FORESTRY

OFFICIAL ORGAN OF THE SOCIETY OF AMERICAN FORESTERS
A professional journal devoted to all branches of forestry

Entered as second-class matter at the post-office at Washington, D. C. Published monthly.

Acceptance for mailing at special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph 4, Section 412, P. L. and R. authorized November 10, 1927.

Office of Publication, Mills Bldg., 17th and Pennsylvania Ave., N. W., Washington, D. C.

Manuscripts intended for publication should be sent to Dr. Henry Schmitz, Division of Forestry, University Farm, St. Paul, Minn., or to any member of the Editorial Staff. Closing date for copy, first of month preceding date of issue.

The pages of the JOURNAL are open to members and non-members of the Society.

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Subscriptions, advertising, and other business matters should be sent to the JOURNAL OF FORESTRY, Mills Bldg., 17th and Pennsylvania Ave., N. W., Washington, D. C.

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JOURNAL OF FORESTRY

VOL. 35 APRIL, 1937 No. 4

EDITORIAL

Forest Education Marches On

IF THE views expressed at the meeting of the Division of Education held in connection with the annual meeting of the Society may be taken as an indication of the prevailing attitude of professional foresters towards forest education, it clearly shows that the profession's conception of the province and responsibilities of forest education is based largely upon false premises.

Forest education in America has many deficiencies. No group is more fully aware of this than forest educators themselves. Strangely enough, however, these deficiencies are seldom specified in the usual "woods-run" of criticism of forest education. All too often the forest schools are blamed for what in fact are academic virtues, and praised for what in fact are academic sins. If the critics of higher education in general, and forest education in particular, sincerely wish to improve its general level, it is imperative that the province of institutions of higher learning be clearly recognized.

The province of a professional school is well defined. It includes at least three legitimate activities: first, the advancement of knowledge; second, the study of problems; third, the training of men.

No longer does any competent observer question the responsibility of institutions of higher learning to contribute to the world's store of accumulated knowledge. If this be a responsibility of the institution, it naturally follows that it is likewise the responsibility of the individual members of staff. Although both the quantity and quality of research carried on at some American forest schools may be somewhat below that of various other scientific and professional departments in the same institutions, this situation, at least in specific instances, is rapidly improving. Many of the younger men added to forest school faculties during the past ten years hold the Ph.D. and have been trained in research methods. Some have developed special fields of research in which they may speak with authority. More important still, these men are imbued with the spirit of research and are carrying on despite such obstacles as heavy teaching loads and lack of much needed facilities and equipment. In many instances, these men have brought a fresh point of view and have given a higher tone to the research programs of the forest schools.

The capacity to teach also has been given consideration in the selection of these men. No longer is it the rule to select merely successful forest practitioners as forest school instructors. In short, forest school faculties today more nearly meet acceptable standards of

scholarship and teaching ability than ever before in the history of American forest education, any and all statements to the contrary notwithstanding.

The second activity falling within the province of a professional school is the study of problems related to its special field. In forestry these problems may have industrial, political, and social implications. In the study of such problems it is often difficult for the investigator not to become involved, even if he should not wish to do so, in the implications of the problem. The situation is further complicated by the fact that a member of staff of a forest school has a dual responsibility; one to the university, and the other to his profession.

There appears to be a great difference of opinion among educational leaders precisely how units of a university such as a forest school should study such problems. Some educational leaders stoutly maintain that the university must not incur responsibility for policies. Dr. Abraham Flexner, in his great book on universities states his position as follows:

"I have been urging that universities maintain contacts with the actual world, and at the same time, continue to be irresponsible. Are the two attitudes incompatible? Can they really take an objective position in reference to social, political, and economic phenomena? Can they study phenomena without wanting to tell legislatures, communities, municipal authorities, and chambers of commerce what they ought to do at any particular moment about some particular thing? I think they must and can. It is a question of ideals and organization. For experimental purposes they may, without sacrifice of intellectual integrity, make suggestions and watch results; but this is different from running a city government, or a political party, involving as such responsibilities do, compromises of principle that are fatal to fearless thinking."

Other educational leaders apparently believe that the university, especially the state university, has a more direct responsibility to the public. They would have the university assume a direct and responsible position in shaping and promulgating policies and programs in the public interest.

Irrespective of whether the university has, or has not, a direct responsibility in shaping and promulgating policies and programs, it is an incontrovertable fact that a university has a responsibility in assembling the data upon which such policies and programs must be based. If members of forest school faculties actively participate in the promulgation of conservation programs, such participation must be grounded on a thorough study and a comprehensive knowledge of the problem. To do otherwise would compromise the position of the university and in the long run greatly detract from the confidence and esteem with which it is held.

The most popular point of attack upon forest schools is their methods of training men. Much of this criticism is trifling or superficial. Although there seems to be little question that the course content and emphasis in various forestry curricula may eventually be improved, it is fallacious to assume that the more progressive forest schools are not constantly studying the problem and that they are unwilling to make changes of unquestionable merit.

The opinion that the forestry content of forestry curricula should be materially reduced seems fairly widespread. Perhaps it should be, but certainly not merely because of the silly belief that forestry courses *per se* necessarily contribute less to the intellectual development of the student than courses taught by other departments of the university. To be sure, professional training in forestry on a four-year college basis should be based on a broad foundation of scientific and cul-

tural subjects preferably largely completed at the end of the sophomore year, and at the same time, it should insure professional preparation adequate for the graduate to meet the requirements of the profession.

Much of the agitation for reducing the forestry content of forestry curricula is based upon the false assumption that it is necessary only to include a few more cultural courses in a professional curriculum to turn out cultured graduates. A considerable amount of experimental evidence shows clearly that this is sheer nonsense. For example, a carefully made study at a leading university of the use of English by students indicates that a single quarter of instruction effected little perceptible improvement, and that a year of instruction yielded slight improvement. The conclusion is drawn that effective use of English may be acquired only by longer training, preferably directed toward specific purposes. The difficulty does not lie in the teaching itself; it rests upon the inadequacy of the administrative arrangement which is based on the assumption that the life-long habits of expression can be modified in a relatively short time.

The problem of giving college graduates a broad cultural background is not to be solved so easily. If this were the case, it would have been solved long ago. Many factors are involved in this question and probably not the least important of these is the actual lack of willingness among large numbers of college students, many of whom, but certainly not all, are in professional courses, to put forth the intellectual effort necessary to acquire culture. Some evidence of this patent fact may be observed in the lack of interest of students to attend or participate in the many extra-curricular cultural and broadening influences available on any university campus.

It is high time that forestry educators recognize once and for all that certain aspects of forestry may be taught on just as high an intellectual level as any other subject taught in the university. No true scholar ever had a sniveling, apologetic attitude towards his own special field of work. If the content of certain forestry courses is not of university calibre, if they cannot be taught on the university level, or if they do not contribute to the student's intellectual development, they have no place in a university curriculum.

In the last analysis, the training, interest, and scholarship of the teacher are infinitely more important in determining the character and quality of teaching than the mere administrative unit of the university in which he finds himself. The true scientist will always teach science and the true scholar will always emphasize scholarship, irrespective of the name of the course in the college catalog. The outstanding need in forest education, as in every other field of education, is more scholarly teachers able to develop in their students that intellectual curiosity which can be satisfied only by high intellectual achievement.

Since the first forest school in connection with an American university was established at Cornell University in 1898, forest education has made constant progress. It has endured the vicissitudes of the pioneer stage. In less than forty years it has developed professional curricula on the university level, the graduates of which have served the Nation with distinction. It is now re-defining and re-casting its objectives and the means of reaching them. The training and scholarship of its teaching staff is rapidly being improved. Research programs are being broadened and strengthened. Much remains to be done, but the old order is changing. A new day is dawning. Truly, Forest Education Marches On!

THE SWEDISH FOREST CONSERVATION COMMISSION

By W. WAYNE LOBDELL

Royal College of Forestry, Stockholm, Sweden

During the past thirty years Sweden has made great progress in developing a rational program of forest management. The state and county organizations and the legislation which made these organizations possible are described. Although there is little likelihood that county forest boards would be successful generally in the United States at the present time, it does not follow that there is no place for a somewhat similar type of board in this country. Mr. Lobdell's article will be found to be of great interest at the moment because of our far greater faith in the efficacy of national than in state forest legislation.

IN THE earliest stages of settlement, some eight hundred years ago, Sweden was covered by vast forests from its most southerly tip to the boreal regions of the north. As in every new country, the forest was an obstacle to settlement and no thought was given to its preservation. With advancing civilization came the settler's ax, border warfare and forest fires—to say nothing of "controlled burning"—laying waste extensive areas. So great was the devastation that in the middle of the 17th century apprehension was felt for the remaining timber. Agitation resulted in the first Forest Ordinance being passed in 1647.

Several other ordinances date from the 17th and 18th centuries. They were designed to limit more stringently the freedom of forest use by certain industries, especially mining, which consumed large quantities of charcoal and timber.

However, the object of this legislation was not attained, and in keeping with the then prevailing opinion that public administration was inefficient, these legal restrictions were abolished. So great was the reaction that the state even relinquished a large portion of its forest land. Forest devastation continued at an increased rate.

With the development of the sawmill and pulp industries in the latter half of the 19th century came the realization that something had to be done to preserve the rapidly disappearing forests, now regarded as an important item of national wealth. However, the legislature could not agree how this should be done. Closely restricted cutting had led to the same unhappy results as unrestricted cutting.

The first legislation affected only those regions in which natural reproduction was difficult to obtain due to climatic or soil conditions. Thus, in 1869, a law was passed requiring forest owners to provide for regeneration after cutting on the islands of Gottland and Öland. A few years later cutting was allowed in the two most northerly län[1] only after the trees had been marked by a state forester. The legislature was still unable to decide on a policy suitable for the varying conditions found in the rest of the country.

At the turn of the century, after considerable investigation, the idea was conceived to create local organizations whose purpose was to awaken, encourage, and guide public interest in forest conservation. County forest conservation boards were subsequently established in January, 1905.

[1]The Swedish "län" roughly corresponds to "county" in administration. It varies in area from 3,000 to 105,000 square km.

Organization

Within each county is found a county council, composed of elected representatives from its towns and districts. One of the functions of this council is to make such decisions concerning the public as development and support of agriculture, industry, forestry, etc. There is also found in each county an agricultural society, an association of land owners interested in agriculture and its allied industries. It is supported chiefly by state grants and conforms to the general regulations of the central government. Members of these two organizations are well informed as to the forest conditions in the precincts they represent.

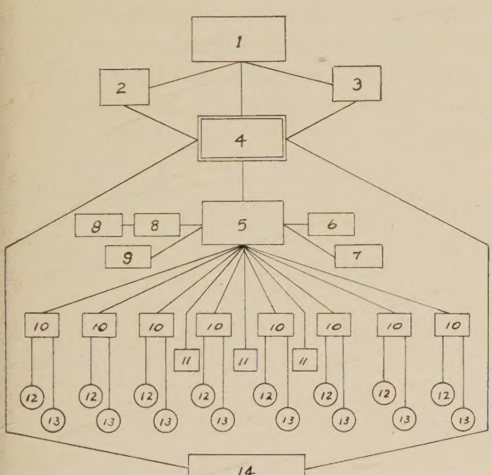

Figure 1.—Organization of the forest conservation board in a medium-sized county. (From Hedemann-Gade, E. "Objects and Methods of Swedish Legislation"—Actes Du Ier Congrés International De Sylviculture—Rome, 1926.)

1. Federal government.
2. County council.
3. County agricultural society.
4. Forest conservation board.
5. County forester.
6. Deputy county forester.
7. Assistant county forester.
8. Accountant and cashier.
9. Clerical staff.
10. County (district) wardens.
11. Extra wardens when needed.
12. Five timber blazers in each district.
13. Ten planters in each district.
14. Forest conservation committees in all parishes of county.

The forest conservation board consists of three members, two appointed by the county council and the agricultural society and the third, who acts as chairman, is appointed by the central government in Stockholm. The members are appointed for a period of three years, and receive no salary. Due partly to the fact that these men receive no salary, the boards have enjoyed a large and increasing amount of popularity. As a result the central authorities have been unable to hand down detailed and iron-bound instructions, but have left the boards with considerable freedom of action within their own counties. This has been perhaps the wisest part of the plan and undoubtedly has had much to do with its success since the law can be adjusted to meet local conditions. It presupposes, however, the selection of men whose prime interest is the public good.

The conservation board meets six to eight times a year and appoints its own assistants. The most important of these is the technically trained county forester, who administers the plans approved by the board. He is also in charge of the rest of the staff, consisting of a deputy and assistant forester, clerks, and wardens who are distributed througout the county. Additional help for forest cultivation and regulation are appointed as required. No appointments are to exceed a period of five years. For this reason and because the men must be well trained, they receive a relatively good salary.

The organization of the conservation board for a medium sized county can best be seen in Figure 1.

From the time the conservation boards were organized until 1925, several laws were enacted to put "teeth" into the activities of the organization. These finally culminated in the Forest Conservation Law, passed in 1923, which will be summarized later. This law applies to the entire country except for portions of

Lapland and alpine areas where cutting is under the control of the state forest service, yet the power of enforcing it was invested in the several independent county boards. The question of uniform application arose, resulting in the formation of the Forest Conservation Boards Union (Skogsvårdstyrelsernas förbund), which meets at least every third year. The work of this union is carried on by a central council, one member of which is appointed by the government and eight others selected from forest conservation boards in different parts of the country. Two county foresters also have a vote.

The duties of this union are to exercise a certain control over the county boards, to give information to the boards, and make decisions on forest and allied questions. No power is held by the council to impose these decisions on the boards, but the latter are expected to give them due consideration. The boards are thus guided in one consistent direction no matter how devious local conditions require their methods to be.

Financial Support

Sweden's forest tax laws are various and complicated. Among them is the "skogsaccis" or severance tax law which was put into effect in the early part of this century. This provides for a tax of 2 per cent on the stumpage value of all trees cut, the money thus collected going into a community fund for schools, roads, etc. At the time the conservation boards were established, an additional 1.3 per cent severance tax was levied on all stumpage value over 100 kronor (about $27). The money provided by this 1.3 per cent tax or conservation dues (skogsvårdsavgifter) formed the larger part of the income available to the boards for the first few years.

Other money was available in the form of grants from the state government, county councils, and county agricultural societies. The extent of these are shown in Table 1.

The organization of the board was designed to disseminate information about forest conservation and good forest practices. Its services were not, however, to be entirely free and unlimited. Trained men were to be available for advice and supervision of planting and timber marking. These services were gratis the first day, but after that time a nominal charge was made. Nurseries were established and trees were sold for reforestation at little above cost. Seed was gathered, cleaned, and distributed at slight expense to the land owner.

As the organization expanded its program, the income from these operations materially increased. This is an essential part of the plan, for in bad years when little cutting takes place in most counties, the income from the severance tax is small, and a surplus in the treasury is the only thing that keeps the organization going.

The finances of each county are separate, and it is up to each board to pay for its own activities. The total income for all county boards is summarized in Table 1. The column for 1915 gives the total for 22 counties, but boards were established in three more counties by 1925. The expenditures of all county boards are given in Table 2.

Work Accomplished

Sweden is about the size and shape of California. Its climate varies from temperate in the south to arctic in the north. In general the soil is a rocky morraine type except in the south, where rock out-crops are less frequent. Due to glaciation, drainage is often very poor and because of the short growing seasons and severe winters, tree growth is slow and regeneration difficult in the northern part of the country known as Norrland. In the south were found areas of drifting sand, and repeated burning had created extensive heath areas supporting nothing but heather. Timber "mining" flourished

in many sections, and farmers were prone to clear cut their woodlots with no intention of assuring reforestation. These woodlots constitute 45 per cent of the total forest area while the state forests make up only 19 per cent. At the same time, forest products had become one of the most important exports, and vital to the economic welfare of the nation. Since 56.5 per cent of Sweden's area is forest land, the task before the conservation boards was indeed great!

It was mentioned before that the purpose of the boards was to bring about forest conservation from "within", i.e. they were to attempt to establish a new forest psychology. Their first step in this direction was to make available information and instruction in forest management. This was accomplished in different ways depending on the resources and ingenuity of the board.

Demonstration forests were established and in some cases the boards bought tracts of land outright. Courses of varying length were given together with practical work on these areas. In some counties, instruction was given in concentrated form at the agricultural colleges and other institutions of learning. School children were given field days, and many excursions were arranged for forest land owners to visit properly and improperly managed areas.

In order to reach all public groups, handbooks and well written articles and pamphlets were distributed free. The local press was brought into service in many communities, and no opportunity was missed to disseminate information. Motion picture films showing the current methods of forest management and utilization of forest products were distributed. These were not only of educational value to the forest owners, but helped to show the general public the aims of good forest management. The educational activities are being continued at present, but less intensively than at first.

An important problem brought before the boards in the southern half of the country was that of afforestation of sand dunes and heath areas. Pine heaths, abandoned pastures and an ever increasing numbers of farms and corporation-owned forest lands on which reproduction was unsatisfactory were found in every part of Sweden. Nurseries were established to

TABLE 1

TOTAL INCOME OF ALL CONSERVATION BOARDS (DOLLARS)[1]

	1915	1925	1935
Balance on hand	127,265	468,128	880,899
Taxes	310,373	472,602	221,247
Grants			
State	42,078	130,654	435,210
County councils	15,535	21,360	23,763
Agricultural societies	13,056	12,023	9,264
Other incomes			
Assistance in management	3,633	34,176	124,344
Reforestation[2]	26,685	134,102	115,962
Drainage of bogs	-------	-------	83,883
Grazing regulation	-------	-------	405
Surveying and legal action	-------	2,404	2,959
Interest, loans, etc.	23,426	102,957	46,609
Miscellaneous	-------	17,128	88,005
Total	562,055	1,392,534	2,032,549

[1]Summarized from the "Skogsvårdstyrelserna Berättelser" for 1915, 1925, and 1935.

[2]Includes income from sale of seed, cones, plants, and charges for supervision.

TABLE 2

TOTAL EXPENDITURES OF ALL CONSERVATION BOARDS (DOLLARS)[1]

	1915	1925	1935
Timber estimating	-------	6,555	3,068
Educational work	14,614	25,378	37,430
Assistance in management	17,748	67,762	245,881
Reforestation[2]	103,023	220,180	171,792
Drainage of bogs	50,336	73,407	89,423
Grazing regulation	-------	2,129	8,003
Law enforcement	-------	54,088	94,303
Administration	105,465	405,042	663,767
Purchase of real estate, etc.	-------	28,584	27,827
Miscellaneous	73,151	113,653	....
Total	364,337	996,778	1,341,496

[1]Summarized from the "Skogsvårdstyrelserna Berättelser" for 1915, 1925, and 1935.

[2]Includes cost of nurseries, seed, planting supervision.

meet this problem. Here plants were raised and distributed to land owners as cheaply as possible. Planting supervision was furnished by the board.

Seed gathering units were organized and central seed cleaning stations were built. During the period 1905 to 1935, some 273 thousand pounds of seed and 311 million plants were distributed, resulting in the establishment of 470 thousand acres of potential forest. Planting activities probably reached their zenith in the period 1915-25. Methods of obtaining natural reproduction have become better understood and more popular and it is toward this goal that the boards are now working. Selection forestry has arrived and apparently will stay in many sections.

Reports show that 15 per cent of the total area of Sweden was economically useless due to swamps and bogs in 1923. Ten years later this was reduced to 9 per cent and drainage is being carried on at the rate of 102 thousand acres annually. Contributions from the conservation boards had made possible the digging and maintenance of 7,700 miles of ditches at the close of 1935. Of this, 50 per cent was accomplished in the last five year period. The total mileage of ditches is several times this amount, but many private owners have undertaken the work themselves through the encouragement and direction of the county foresters. The state forest service has also contributed a great deal toward solving the problem.

Considerable attention is now being directed to grazing regulation. Demonstration grazing areas have been fenced and through excursions to these areas many farmers have been won over to more sound grazing practices.

The requests for advice and instruction in logging practices, management, and silviculture have increased from a yearly average of 1,339 during the period 1905-09 to 35,878 during the period 1931-35. This has required a large increase in personnel. The number of county foresters, deputies, and assistants increased from 27 in the first period to 78 in the latter. Likewise, the number of district wardens has increased from 82 to 255, and planters, woods foremen, etc., from 348 to 1,017.

The above figures are strong evidence that the conservation boards are winning the confidence and support of the private forest owners. The pioneering stage has been passed successfully and the boards have established themselves as an indispensable part of the community.

Legislation

It might appear from the above statements that the success of the conservation boards would have resulted from education and direction alone. It is doubtful, that even with more generous financial backing in the form of grants, the plan would have succeeded without the reserve power invested in the organization by the Forest Conservation Law.

When the boards began operations, their sole weapon was the Law of 1903, concerning the care and management of all private forests. This law went into effect in 1905 and dealt only with regeneration. It specified that anyone who felled timber in such a way that regeneration was jeopardized was under obligation to restore the soil to such a state that forest growth would again be possible. This principle was already being applied by many far-sighted owners, but since the remainder enjoyed entire freedom in managing or mis-managing their forests, it was fortunate that more stringent regulations were not imposed at that time.

It was soon obvious, however, that this law would, in itself, not be sufficient. With the outbreak of the World War forest legislation was neglected for a time. Encouraged by high prices, young stands were severely cut to meet the wartime demand for timber. Consequently,

an investigation was made of the type of legislation required to protect the remaining stands of timber. A provincial law was enacted in 1918 to protect the "younger stands in full growth" until this investigation could be completed. This law provided Parliament with an opportunity to experiment, and as a result, the Forest Conservation Law of 1923 was passed. This law later (1925) was made to embrace the entire country except those parts of Lappland and the mountain areas previously mentioned. The law was broadly formulated so that it would apply to widely varying conditions. The chief points may be summarized as follows:

1. Forest land shall bear forests; therefore conversion to any other purpose may take place only under certain conditions (after an examination by the county forester).

2. Cutting in "younger" forests must be in the form of thinnings, carried out in such a way that the development of the stand is promoted.

3. Cutting in "older" stands may take place only to such an extent that the supply of timber on the property itself shall not be jeopardized.

4. If cutting results in the stand being unreasonably thinned and satisfactory reproduction cannot be looked for within a reasonable time, measures shall be taken to secure reproduction.

5. Cutting for sale may take place in forests subject to impeded regeneration only after permission has been granted by the forest conservation board.

6. If cutting is carried on in conflict with regulations laid down by law, the forest conservation board is empowered to issue a cutting prohibition. If cutting is carried on in defiance of such prohibition, relatively high fines may be inflicted and the timber confiscated.

The term "younger forest" is interpreted by the boards as being those stands which are in full growth and which will continue to show value increment. "Older" stands are those now so old or in such condition that there will be little increase in value if they are allowed to remain uncut.

As may be expected parts of this law met with heated disfavor from some of the land owners. That it was a wise law, is indicated by the attitude of the general public in supporting it. The number of law-enforcement cases have dropped decidedly in the last few years, and annual cutting prohibitions have decreased from 365 to 161 in the last fifteen years. That the law has been efficiently and justly applied, in spite of its vague wording, is indicated by the vote of confidence recently given the conservation boards by Parliament.

This plan of forest control probably will not be successful in all countries. Yet it is interesting to note how, in a span of thirty years, Sweden has drawn close to its goal of rational forest management on a permanent basis.

A YIELD TABLE FOR NORTHERN HARDWOODS IN THE LAKE STATES[1]

By S. R. GEVORKIANTZ and WILLIAM A. DUERR

Lake States Forest Experiment Station

The prediction of volume growth in timber stands by means of a yield table offers certain unquestioned advantages over other growth-prediction methods, especially in its straightforward approach and ease of application. The normal-yield table, however—based upon stand age, and defining site in terms of height of dominant trees—has not been applied successfully to all-aged stands like those of the northern-hardwoods cover type, chiefly because of the variation in age among individual trees in the stand. A yield table for average well stocked stands of northern hardwoods in the Lake States, based on the average age and the average diameter of the main stand has been prepared by the author.

A RECENT study of northern hardwoods undisturbed by cutting or fire indicated that there is present in each stand a main, comparatively even-aged group of trees, which accounts for most of the basal area and whose members have apparently originated in a body during the course of a few years. Beneath this main stand is a group of newcomers, all considerably younger than the rest; and above it a scattering of old trees, members of a former stand. An analysis of the field data collected by the Forest Survey in the Lake States has shown that only a small error is involved in determining the average age of this main stand, and that this average-age value is a significant and usable one.

Description of the Table

The following yield table for the northern-hardwoods cover type is based upon the average age and the average diameter of this main stand. It represents the development of ordinary well stocked, undisturbed timber in the Lake States.

Site.—Three site conditions are recognized. The quality of site upon which timber is growing is determined from the relationship between age and average diameter of the main stand. The better the site the younger the stand for the same average main-stand diameter.

Age.—Main-stand age is the average age of main-stand trees only. It has been found that it is not necessary to sample the entire main stand in order to determine its age. A reliable average may be obtained from the ages of certain key diameters, depending upon the size class of the stand in question.

Table 1

KEY DIAMETERS FOR DETERMINING AVERAGE MAIN-STAND AGE

Size class[1] (inches)	Key diameter classes[2] (inches)
1-5 (small poles)	2, 4
3-9 (cordwood)	6, 8
9-15 (second-growth sawtimber)	10, 12, 14
15+ (old-growth sawtimber)	14, 16, 18, 20

[1]The size classes are those used by the Forest Survey. Stands containing 2,000 board feet or more per acre are called 9-15 if more than half of the volume is in trees less than 15 inches in diameter; otherwise they are called 15+. Other stands are classified 3-9 if they contain 3 or more cords per acre in 6- and 8-inch trees; 1-5 if they are stocked with small poles having a volume of less than 3 cords per acre.

[2]The 2-inch diameter class includes trees with breast-high diameters of from 1.0 to 2.9 inches, inclusive.

[1]This table is a byproduct of growth studies made by the Forest Survey in the Lake States.

Average Diameter.—Average main-stand diameter is the average diameter of main-stand trees only, calculated in the usual way (weighted by basal area). Here, again, it is not necessary to define strictly the limits of the main stand. A close approximation of average main-stand diameter may be obtained by computing the average diameters of all trees belonging to certain diameter-class groups (Table 2).

TABLE 2

DIAMETER-CLASS GROUPS FOR DETERMINING AVERAGE MAIN-STAND DIAMETER

Size class (inches)	Diameter-class group (inches)
1-5 (Small poles)	2 through 6
3-9 (cordwood)	4 through 20
9-15 (second-growth sawtimber)	6+
15+ (old-growth sawtimber)	10+

Number of Trees and Basal Area.—These apply to the entire stand of sound trees 1 inch or larger, d.b.h. Cull trees are not considered.

Volume, Merchantability, and Growth.—Board-foot volume is given for trees 9 inches or large d.b.h.; top diameters are variable, the minimum being 8 inches inside bark for hardwoods, 6 inches for conifers and aspen. Trees 9 to 17 inches in diameter have been omitted from consideration if they would not produce at least an 8-foot log of high quality or a 16-foot log of low quality; larger trees were considered unmerchantable unless they would produce at least one high-quality or two poor-quality 16-foot logs. Stump height is 1 foot for trees up to 18 inches d.b.h., 2 feet for larger trees.

All board-foot volumes represent the scale of sawlogs only, and are net: Cull trees and woods and mill cull have been deducted. The woods cull allows for long butts and other sections of merchantable trees commonly left in the woods (but not for cull sections lying above the merchantable height), and mill cull or for losses in milling due to sweep, rot, shake, or other defect. Cubic-foot and cord-wood volumes are the gross volumes, excluding bark, of sound trees 5 inches or larger in diameter breast high, to a top diameter of 4 inches inside bark. Cordwood is assumed to be piled with the bark on.

The utilization standards described above should be kept in mind in interpreting growth as shown by the yield table. While growth in cubic feet or cords is self-explanatory, it may be stressed here that growth in board feet represents growth of sawlog material only, after woods and mill cull have been deducted. Furthermore, it does not consider growth in standing cull trees or in the upper portions of tree stems where defect, deformity, or branches make the wood unsuitable for sawlogs. For this reason the net growth obtainable from the yield table may appear somewhat too low or conservative to those who are more familiar with gross increments, or who prefer the use of volume tables to a fixed top.

APPLICATION

In order to use the yield table to predict growth in a stand of northern hardwoods, three things must be known about the stand:

1. Average volume per acre.
2. Average main-stand age.[2]
3. Average main-stand diameter.[2]

Take as an example a 500-acre tract of second-growth (9-15) northern hardwoods

[2]The two values, average main-stand age and average main-stand diameter, are used together to determine site. If only a rough determination of site is required, the descriptions of "typical areas" in the yield table may be used. In this case either one of the two values alone will suffice for the rest of the growth calculation.

TABLE 3

YIELD TABLE FOR AVERAGE WELL STOCKED STANDS OF NORTHERN HARDWOODS IN THE LAKE STATES

Main-stand age (years)	Average main-stand diam. (in.)	No. of trees per acre	Basal area per acre* (sq. ft.)	Volume per acre: Sawtimber board feet: Scrib.	Int. ¼″	Total volume: Cubic feet	Cords	Basis (number of plots)
Good site								
Typical areas: Lower Peninsula Michigan and parts eastern Wisconsin								
40	7.4	290	86	950	1,200	1,320	23	21
60	9.6	205	102	3,550	4,300	2,130	37	5
80	11.6	160	115	6,100	7,200	2,770	47	8
100	13.3	130	127	8,550	9,900	3,330	55	5
120	15.1	110	137	10,750	12,200	3,790	61	2
140	16.8	95	146	12,600	14,100	4,210	66	....
160	18.6	80	155	14,100	15,600	4,530	70	....
180	20.4	70	162	15,300	16,750	4,790	73	1
200	22.1	65	168	16,300	17,700	5,000	75	...
Basis								42
Medium site								
Typical areas: Upper Peninsula Michigan and parts western Wisconsin								
40	5.6	480	82	300	400	740	13	12
60	7.8	295	97	1,600	2,000	1,350	24	7
80	9.5	220	109	3,500	4,250	1,930	33	1
100	10.9	185	119	5,350	6,400	2,450	41	2
120	12.2	155	128	7,200	8,450	2,890	48	3
140	13.5	135	136	8,850	10,200	3,270	53	3
160	14.8	120	143	10,300	11,700	3,580	58	4
180	16.1	105	149	11,500	12,950	3,830	61	3
200	17.4	95	155	12,600	14,000	4,050	63	....
220	18.7	85	159	13,450	14,900	4,230	65	....
240	20.0	75	163	14,200	15,600	4,380	67	2
Basis								37
Poor site								
Typical areas: Central Minnesota and sandy lands, Michigan and Wisconsin								
40	4.1	770	71	100	150	360	7	4
60	6.0	435	85	400	500	650	12	9
80	7.6	305	96	1,200	1,500	1,030	18	3
100	8.9	245	105	2,550	3,150	1,450	25	...
120	10.0	210	113	3,800	4,600	1,820	31	1
140	11.0	180	119	5,000	5,950	2,180	37	3
160	11.9	160	125	6,150	7,250	2,500	42	3
180	12.9	145	130	7,300	8,450	2,780	46	4
200	13.8	130	134	8,300	9,550	3,020	49	...
220	14.8	115	138	9,300	10,600	3,220	52	1
240	15.7	105	142	10,200	11,500	3,390	54	1
260	16.7	95	145	11,000	12,350	3,540	56	...
Basis								29

in Wisconsin. The owner desires an estimate of current growth in board feet Scribner for the next 10 years, and is able to make a 10-per cent cruise for this purpose. The recommended procedure is as follows:

A cruise is run, using fifth-acre sample plots. In addition to the regular tally on all plots, on every plot which shows no evidence of disturbance by cutting or fire total-age borings are taken in the three trees of the 10-, 12-, or 14-inch diameter class (Table 1) which stand closest to the plot center.

From this cruise the average volume per acre is found to be 3,660 board feet net Scribner, according to the standards set up under "Volume, Merchantability, and Growth."

The average age of all sample trees bored is 80 years.

A stand table is compiled, using only the undisturbed plots, and the average diameter of trees in the 6-inch and larger diameter classes (Table 2) is found to be 11.4 inches. This is assumed to be the average main-stand diameter.

Reference to the yield table shows that an 80-year old stand with average diameter 11.4 inches falls closest to good site. The volume on good site at 80 years shown by the yield table is 6,100 board feet Scribner; at 90 years (10 years later) it is 7,325 board feet (by interpolation). Ten-year yield-table growth is thus

$$7{,}325 - 6{,}100 = 1{,}225 \text{ board feet.}$$

The degree of stocking of this stand, compared to the yield-table volume at the same age, is

$$\frac{3{,}660}{6{,}100} \text{ or } 0.60.$$

Current 10-year growth for the stand in question can now be found by using the formula:[3]

$$G = dg\ (2 - d)$$

where

G=10-year growth in a timber stand.
d=degree of stocking of that stand at the beginning of the 10- year period.
g=corresponding growth shown in the yield table.

Thus

$$G = 0.60 \times 1{,}225\ (2 - 0.60) = 1{,}029.$$

Current 10-year growth in this stand of hardwoods is therefore 1,029 board feet net Scribner, or 103 board feet per acre per year.

[3]This formula, devised by Gehrhardt, expresses the approach to normality, or "acceleration", of understocked stands of tolerant species. It has been found applicable to stands of northern hardwoods. Since the formula applies only to a 10-year period, growth estimates for longer periods must be made in 10-year steps, using a new value of "d" at each step.

FOREST SOIL PROBLEMS IN THE PIEDMONT PLATEAU[1]

By T. S. COILE

Duke Forest, Duke University

The problems concerned with the relation between soil characteristics and timber growing have received only sporadic attention from investigators in the United States until very recently. Even now, only a few individuals are able to devote all or a part of their time to forest soil research. Research in forestry has been going through the measurement and inventory stage; little attention being given to the complicated problems involved in the interaction between the soil and the forest. Many elaborate and involved investigations on growth, yield, and reforestation have been made; but their objectives have largely been the measurement of an existing condition without attempting to determine why it obtains.

FOREST soil problems are, to a large degree, regional in character. The wide differences in climate, soil conditions, and vegetation in different parts of the United States result in many diverse forest soil problems. Therefore, application of results of researches on these problems is regional rather than universal.

A discussion of forest soil problems in the Piedmont must be preceded by a brief introduction to the soils of the region. The soils of the Piedmont Plateau belong in the red and yellow soil group as recognized by Marbut (12, 13). The residual soils are developed from pre-Cambrian crystallines and Triassic sedimentary rocks. Bottomland soils are developed from alluvium dropped by streams which drain the watersheds. The nature of the sediment is determined by the character of the residual soils on the watersheds. The upland or residual soils are old, and where erosion has not been excessive, they have well developed profiles.

The nature of the climate has resulted in the development of soils intermediate in profile characteristics between the podsolic soils of the north and the lateritic soils of the south. Mature soils whose parent material is high in iron and aluminum, such as those developed from ferromagnesian rocks, are distinctly lateritic in character; although evidence of podsolization can be seen in all the uneroded upland soils under forest cover.

Within this region the nature of the soil has been largely determined by parent material, topography, and erosion (3). In the Piedmont of North Carolina the annual precipitation varies from 40 to 50 inches, and the average annual temperature ranges from 56° to 60° F. The region is characterized by long warm summers and short mild winters. The surface soil is seldom frozen in winter to a depth of more than a few inches (U. S. Dept. Agr., Weather Bur.).

In general the residual soils are occupied by oak communities, if they never have been cultivated, and by pine communities (loblolly pine, shortleaf pine, and virginia pine) if they have been cultivated. The climax forest on the uplands is oak-hickory.

Forest soil problems in the uplands can be divided into two broad groups: (1) those concerned with recognizing inherent properties of various soil conditions that are associated with the presence of various forest types under normal succession, and with various productivity

[1]Presented at the meetings of the American Association for the Advancement of Science, December 1936, Atlantic City, N. J.

or site classes for forest stands; and (2) those concerned with the influence of individual species, mixtures of species, and stand density on soil productivity through the periodic return of organic debris to the surface soil. The first category represents studies of inherent soil properties that are essentially permanent and can be influenced but little by silvicultural practice, while the second category represents studies of soil properties, and forest and soil interactions that may be modified by the silviculturist.

Within the Piedmont there are many different soil conditions because of wide differences in the petrological and structural nature of the parent material; the topographic position, which influences weathering; and erosion, which effects the removal of surface soil.

As a result of a study made on the relation of site index for shortleaf pine to certain physical properties of the soil (5), it is known that the height growth of pure, even-aged stands of shortleaf pine on old fields is correlated with depth of the A horizon and the amounts of the finer fractions, silt and clay, in the B horizon. A part of the Duke Forest lies in the Durham Basin of the Deep River Triassic area, the soil of which belong to the White Store and related series. They have light-textured, sandy loam, surface soils and heavy-textured, clay, subsoils. Under past agricultural practice they have been the most severely eroded of all Piedmont and North Carolina soils. As a result, the existing profiles range from normal A B C soils—all three horizons present—with 10 to 12 inches of A horizon, to those having only B and C horizons and sometimes with a part or all of the B horizon removed by erosion. The latter condition represents the poorest soil for pine in the region. The heavy compact nature of the B horizon of White Store soils make them inhospitable to the growth of roots of desirable trees, particularly in this region where prolonged dry periods often occur during the growing season. In contrast with the low site quality of eroded White Store soils, an eroded Davidson clay, developed from gabbro or gabbro-diabase; or an eroded Georgeville, developed from basic volcanic rock, each with the entire A horizon absent, may be of a site quality as good or better than the normal White Store soil. This is because the B horizons of the latter two soils, although heavy in texture, are relatively open and friable, allowing good water percolation, and good aeration, both of which are conducive to good root development.

Coile (7) found high correlation between precipitation during the spring months and growth of pine in the southern United States. The concentration of small roots near the surface of forest soils in this region indicates the necessity of an adequate amount of precipitation during the growing season (8).

The eroded phases of two other soils, Orange and Iredell, are of unusually low site quality for both pine and hardwoods. Both soils have heavy, tough, plastic clay subsoils which are not associated with good tree growth. Even when uneroded they normally support a white oak-post oak forest, as compared to a white oak-black oak-red oak forest on the red soils. Eroded areas may support a still more xeric forest, the post oak-blackjack oak type.

The inherent and more or less static profile characteristic of Piedmont forest soils that is a function of the nature of the parent material, its topographic position, and the amount of erosion that has taken place, cannot be changed by the silviculturist. They will obtain 100 years from now about as they do today. However, we can go far in recognizing and correlating various inherent profile characteristics with different forest types and different productivity levels for forest

trees, and thus predicate a more rational silviculture on our different soil conditions, and effect an evaluation of forest land based on its productive capacity for forest crops.

The second broad category of soil problems in the Piedmont region is concerned with the effects of the vegetation on forest soil fertility and the reciprocal relations of forest and soil. The characteristics of the Ao and A horizons can be changed by the silviculturist through modifying stand composition and density. The periodic return of organic debris to the surface of forest soil is analogous in many ways to the application of fertilizers or the plowing-under of cover crops in ordinary agricultural practice. The nature of the organic debris and the environment under which it decomposes determines to a large degree the nature of decomposition products and their effect on soil fertility.

Lunt (10, 11), Plice (16), Melin (15), Garstka (9), McHargue and Roy (14), Tenney and Waksman (17), Waksman, Tenney, and Stevens (18), and Coile (6) have shown that there is a characteristic difference in the chemical composition of mature undecomposed litter of different species of forest trees, and in the effect of environmental conditions on decomposition. Alway and Kittredge (1), and Alway, Methley, and Younge (2) found differences in the chemical composition of the forest floor under stands of conifers and of hardwoods in Minnesota.

It is known that on the same soil different species of trees have characteristically different composition of bases and nitrogen (6). The chemical composition of mature litter and the environmental conditions under which it decomposes has a profound influence on the development of various forest humus types; on release of the mineral constituents of the organic debris; and on mobilization of available nitrogen.

The total nitrogen content of litter has an important influence on rate of decomposition and the time required before decomposition reaches a stage when nitrogen locked up in microbial protoplasm is made available for root absorption. White oak and black locust litter contain relatively large amounts of nitrogen. The decomposition of the former is inhibited, however, by the presence of tannins and silica, while the latter decomposes quickly.

The amounts of basic mineral elements in litter are of importance because of their influence on soil reaction, and hence the rate and type of decomposition, and their absorption by tree roots. Litter of yellow poplar, red cedar, and dogwood is relatively high in calcium, while that of pines and oaks is relatively low. In addition pine litter is low in nitrogen and high in resins and waxes which inhibit decomposition.

Calcium influences decomposition through its influence on reaction, which in turn has a profound influence on the microbial population that feed on organic matter, obtaining energy from the carbohydrates and eventually releasing nitrogen in a form available for root absorption and plant use. Coile (4) found the organic horizons under different forest types in the Duke Forest to have characteristically different reactions.

The pertinent problems in the second category involve studies of the chemical nature of mature undecomposed litter of the various species in the region; both those that make up the dominant stand and the understory species which may have a decidedly beneficial effect on soil fertility. The next step after the original composition is understood is to study the rate and type of decomposition of various kinds of forest organic debris in the forest and under controlled conditions, identify the important organisms and groups of organisms that cause different types of decomposition and different de-

composition products. This line of investigation logically leads to studies of forest humus types. Knowledge of the various humus types that obtain in the region will enable a silviculturist to recognize desirable and undesirable conditions which he may modify by changing stand composition or density, or both.

The humus type developed in any specific locality is a function of chemical composition, physical character and amount of fresh organic debris, and environmental conditions (heat, light, and moisture) under which it decomposes. All of these influence the kind and amount of the micro- and macro-organisms which directly or indirectly cause reduction of organic matter.

It is already known that litter of certain understory species, such as dogwood, contain a relatively large amount of calcium, while litter of pine is extremely low in calcium (6). It appears likely that such understory species that occur in both pine and oak stands have a very beneficial effect on soil through their influence on decomposition. A mull humus type exists under clumps of dogwood in the Duke Forest while the humus type under mature stands of pine and under oak is mor-like in appearance.

By modifying the humus type foresters are able to regulate the productivity of forest soils on which stands already exist. By being able to recognize inherent properties of the soil that are uninfluenced by forest cover, they are better able to mold stand composition and stand densities to fit specific soil conditions, and on open areas to plant species whose growing habit is particularly adapted to the various soils.

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A NEWS film of the Harvard Forest models has recently been made and released by Pathe. It is Pathe Topics No. 4 and is being distributed by the R.K.O. Distributing Corporation, Boston, Mass. Interested groups can often persuade a local theater to order such a film, especially if it is not on their regular list.

A description of the forest models, which are unique both in technical and artistic excellence, was contained in the December 1936 JOURNAL OF FORESTRY.

OPEN TANK CREOSOTE TREATMENT OF SHORTLEAF AND LOBLOLLY PINE POLES

By E. J. DOWNEY

Texas Forest Service

Poles and posts treated at commercial plants are not always readily available. The Texas Forest Service overcame this difficulty by erecting an open tank treating plant. By reheating the material after the cold bath treatment it was found possible to decrease the volume of creosote absorbed, and at the same time increase the depth of penetration.

THE Texas Forest Service, since 1928, has successfully employed the regular prescribed open tank creosoting treatment to satisfy a portion of its needs for such material as fence posts, small telephone poles, cattle guards, etc. This regular treatment consisted of heating the material in a creosote bath from one to two hours at temperatures ranging from 180° to 210° F. and then allowing the bath to cool for five or six hours to obtain the desired penetration.

The recent expansion in the area protected by the Texas Forest Service required some 10,000 small poles for the initial installation of an adequate telephone system which increased the total mileage of telephone lines to over 1,100 miles. It is estimated that about 1,000 poles will be required annually for renewals and it was deemed advisable to make the necessary changes in the creosoting facilities to permit the thinnings from the State Forests to be utilized toward firing, in so far as possible, this increased demand for small telephone poles.

The enlarged plant consisted of two rectangular tanks 3′ x 3′ x 18′, installed in a manner to provide space under each for firing. An overhead system of blocks was rigged, as shown in Figure 1, to facilitate the handling of an entire charge of poles as a unit. Ample yard space was provided for the most convenient handling of both treated and untreated material. The yard was equipped with a narrow gauge track which supported a specially constructed tram car capable of carrying a full charge of poles that could be transferred from the car directly to the vats as one unit.

The two vats were carefully calibrated and tables were made to show the contents at the various depths for each degree change in temperature thus allowing the operator to determine the depth and temperature of the creosote in the vats and from the tables determine the gallonage computed on the basis of creosote at 100° F. which is the standard used by the American Wood Preservers Association.

The cubical contents of each charge were accurately figured, using the volume table as given in the "Manual of Recommended Practice" prepared by the American Wood Preservers Association, and records carefully kept on the behavior of each charge treated.

In treating the first six charges the hot vat was kept around 190° F. while the cold vat was allowed to remain at air temperature which averaged around 90° F. The poles were shortleaf (*P. echinata*) and loblolly pines (*P. taeda*) with top diameters averaging 3.5 inches and butts averaging 4.5 inches. It was found necessary to heat the poles in the hot vat for a period of two hours to obtain the desired temperature throughout each pole. At the end of this period the charge was transferred to the cold vat as quickly as possible and allowed to re-

main for two hours, submerged in creosote at a temperature ranging from 90° F. to 100° F.

This treatment gave an excellent penetration of creosote, averaging two inches at two feet from the butt end of the pole where the borings were made to avoid confusion from end penetration. However, the amount of creosote used ranged from 18 to 20 pounds per cubic foot which is an unusually heavy treatment for this type of material. Cross sections revealed that the distribution of the creosote in the treated area ranged from a super-saturated condition in the outside area gradually decreasing to a stained appearance at a depth of two inches inward. Such a distribution would undoubtedly give the desired protection but observation showed excessive loss of creosote by bleeding. Even after bleeding had apparently ceased it was found that ample creosote remained in the pole to protect it. The problem now was to reduce the amount of creosote used per cubic foot in an effort to decrease the cost and at the same time avoid the loss through bleeding.

Several experiments were conducted, such as reducing the length of the period in, first the cold vat, then the hot vat, and finally in both vats. Each time the result was not only a decrease in the amount of creosote used but also there was a marked loss in the depth of penetration. This loss resulted in penetrations being obtained only to depths ranging from one-half to three-quarters of an inch and, because season checks were often found in the treated material to

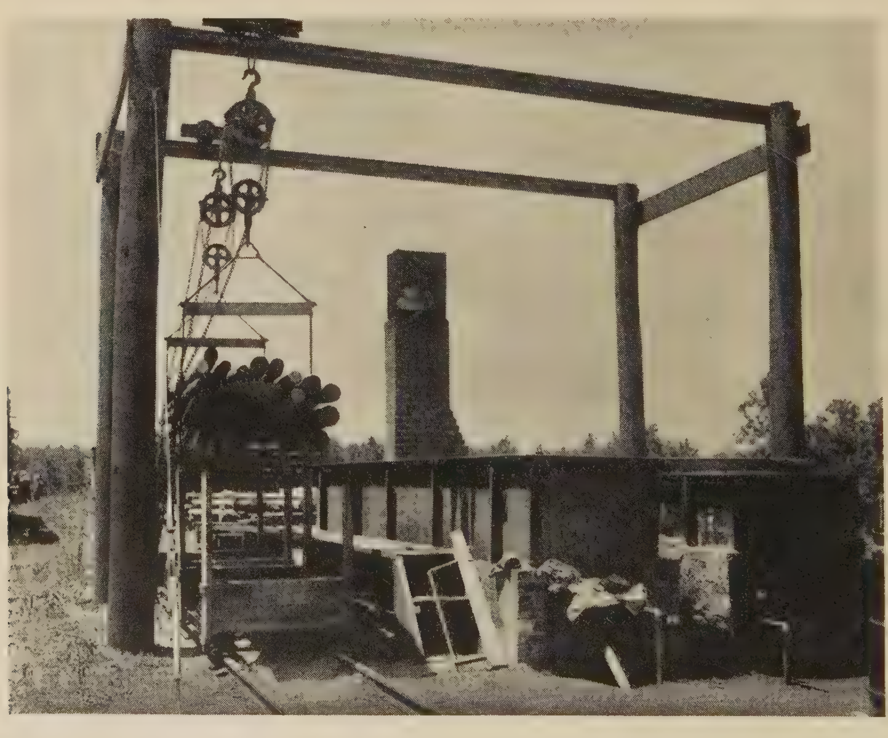

Fig. 1.—General view of open tank creosote plant built and operated by the Texas Forest Service on State Forest No. 3 at Maydelle, Texas. Note the two tanks which are used respectively for the hot and cold treatment of the poles and the conveyor system with a charge of poles ready to load into the vat.

have opened as much as 1.5 inches deep after treatment, it was evident that such light penetration was not satisfactory.

It was then thought that the difference in temperature between the hot and cold vats was not sufficient to give the desired penetration. The temperature used in the hot vat was increased to range between 220° F. and 225° F. with the result that the penetration was again increased to depths of from 1.5 to 2 inches with a consistent average of 1.75 inches, but still excessive amounts of creosote were used and bleeding continued. The final retention was found again to be ranging from 18 to 20 pounds per cubic foot and with creosote at 21 cents per gallon and an average cubical content per pole of 1.88 cubic feet, meant a cost of about 86 cents per pole for creosote alone.

To determine if all of the creosote used went into the poles and not lost through evaporation, the hot vat, on three different occasions, was filled to the working level, amounting to 575 gallons, and heated at 220° for ten hours. Each time measurements were taken at thirty minute intervals throughout the heating period and on each occasion the loss chargeable to evaporation was found to be about 1 per cent. It was felt that because the loss was less than six gallons over a ten hour period, during which time a daily average of 100 poles was treated, it could be ignored. Six gallons distributed over 100 poles would amount to about .04 gallons per cubic foot.

Fig. 2.—Two cores and cross section of a pole treated by the reheat process. Note in the cross section that penetration has been secured in all but a small portion of the center. Penetration obtained by the reheating method averaged 1.83 inches on over 5,000 pieces of material treated.

The problem of reducing the amount of creosote used and at the same time obtaining sufficient penetration still remained unsolved.

The theory of the whole process was then carefully considered and the thought occurred that if the poles were first heated for the purpose of expanding the air and water within the pole it should be possible to reheat the treated pole after its period in the cold vat and force part of the creosote out by causing it to be rapidly expanded.

Weiss, in his book, "Preservation of Structural Timber" suggests on page 56 that reheating the material after removal from the cold bath tends to drive out a part of the creosote. He does not state whether this suggestion is based on theory or on facts. A careful survey of the literature on this subject in the Texas Forest Service library disclosed no additional reference as to the reheat process.

The charge of poles was first heated in the hot vat at a temperature ranging from 220° F. to 225° F. for a period of one hour and then as quickly as possible transferred to the cold vat which was kept as near 100° F. as possible. The charge was allowed to remain in the cold vat usually one to one and one-half hours, or until a penetration of about one inch was shown by borings taken at least two feet from the butt end, at which time it

was again transferred to the hot vat and allowed to remain for thirty minutes at 225° F.

By reheating the charge taken from the cold vat it was found that the resulting expansion of the creosote not only drove out part of the surplus but also acted to push creosote deeper into the pole giving a very even distribution throughout the treated area. Thus poles taken from the cold vat showing a penetration of one inch came from the reheat period in the hot vat with a penetration averaging 1.83 inches and often showing complete penetration as shown in Figure 2.

By this method the final retention was reduced from 18 to 20 pounds per cubic foot to an average of 12.8 pounds per cubic foot and bleeding was entirely stopped. While 12.8 pounds of creosote per cubic foot is more than ample to assure protection, it was found necessary to use this amount to obtain the desired penetration by open tank methods.

To date the Texas Forest Service has treated a total of 148 charges, covering 3,420 small 17½-foot poles and 1,895 fence posts, using this reheat method. The average penetration obtained was 1.83 inches with an average retention of 12.8 pounds per cubic foot. It is believed that the reheating procedure deserves further consideration and should be of interest to farmers and others using the open tank method of preservative treatment with creosote.

U. S. Forest Service Notes

E. N. MUNNS, formerly chief of the Division of Silvics in the U. S. Forest Service, has been appointed chief of the newly created Division of Forest Influences.

D. I. T. Haig, who had been assistant to Munns in the Division of Silvics, has been named acting chief of that division.

L. G. Hornby of the Northern Rocky Mountain Forest and Range Experiment Station has been placed in charge of a special fire control planning project for the Forest Service. His assignment, which will require three years for completion, is to bring the newest scientific developments into fire control in the National Forests and to coordinate the results of the past thirty years of experience.

APPLICABILITY OF THE SELECTION METHOD IN NORTHERN HARDWOODS[1]

By F. H. EYRE and J. R. NEETZEL

Lake States Forest Experiment Station

Selective logging has been widely advocated for many forest types during the past several years, sometimes without due regard to the silvicultural applicability of the method. This article, based on carefully conducted cutting experiments in mature northern hardwoods, presents the reaction of the forest to the selective method as well as to clear cutting

THE pros and cons of selective logging in northern hardwoods in the Lake States based on mill-scale data giving the returns from cutting small- and large-sized logs, have been more or less thoroughly discussed verbally and on paper during the past ten years. In all of the published articles, however, growth and silvicultural behavior of the stands were either assumed or founded on extensive surveys of cut-over areas. No real selective cuttings were available from which intelligent conclusions could be drawn. Or were there commercial cuttings with adequate records and descriptions of the stand before and after logging, let alone data on growth of the residual trees.

Consequently, the Lake States Forest Experiment Station began in 1926 to obtain reliable information on growth, mortality, and reproduction of such stands under selective cutting by actual trial. An excellent tract[2] of land was provided by the Cleveland-Cliffs Iron Company in Marquette County, Mich., and arrangements were made with the Company through a cooperative agreement to test out any method desired by means of experimental cuttings.

The fact that the area was readily accessible, (the average haul to the railroad was somewhat greater than one mile) and a market existed for chemical wood, mine timbers, and ties as well as saw logs, has made it possible to dispose of almost any kind of material. Therefore, all degrees of cutting were tried. These ranged from an absolute clear cutting (of everything, including cordwood), to a light selective cutting which removed only one-quarter of the merchantable saw-timber. Observations were also carried out on a virgin tract in order to provide a comparison with the cut-over areas.

The logging, carried on during eight different years, was done under contract by local farmer-loggers who used their farm horses and equipment for woods work. Because they had no investment in permanent logging improvements such as camps and railroads to liquidate, they were able to "bid-in" the light selective cuttings at no increase in cost over those operations on the tract where all the merchantable trees were cut.

The logs removed from the selective cuttings brought from $16 to $31 per thousand board feet loaded on cars which gave a return for stumpage and profit from $5.45 to $19.57 per M log scale. An additional return was received in each case from chemical wood. The lowest return from saw-logs ($5.45 per M) came in 1930 when the selling price of lumber

[1]Acknowledgment is made of the large contribution to this study by E. L. Mowat who established the greater part of these cutting experiments; to R. H. Blythe, Jr., who assisted with the computations; and to Raphael Zon under whose direction the entire project has been carried out.

[2]This area of 640 acres has been enlarged through purchase to 4,800 acres and is now known as the Upper Peninsula Experimental Forest, which is operated as a branch of the Lake States Forest Experiment Station.

was on the down grade, but while a relatively high contract rate for logging still prevailed. The highest price was obtained in 1926.

Eleven different contiguous cuttings have now been made totaling over 220 acres. On each cutting unit one or more permanent sample plots have been established to furnish information on growth, mortality, and reproduction. Five-year records, now available for eight cutting units varying in size from 5 to 30 acres, provide the basis for this report.

Description of Stand

Before the cuttings were started the stand was practically virgin in character. An extremely light cutting during the period 1906-10 had removed some of the large elm and basswood but apparently did little to disturb the natural condition of the forest. The stand at the time these cuttings began was largely overmature, but contained trees of all ages from seedlings to veterans of 360 years. Although there was a great range in age, the bulk of the saw-log timber was well over 200 years old.

Sugar maple comprised about 80 per cent of the number of trees and over 85 per cent of the volume before cutting. Yellow birch was second in importance while American elm, basswood, ironwood, and balsam fir were found occasionally. Hemlock and beech were practically absent.

The site was comparatively good. The average dominant tree attained a height of 90 to 100 feet. After deducting one-third for cull there was still an average of 10,500 board feet per acre.

Two types of soil are represented in the plots covered in this report, Chatham loam and Trenary sandy loam.[3] The latter varies from sandy loam to loam, some of which contains considerable gravel. The Chatham loam, a well drained soil, would seem to be slightly better for tree growth than the Trenary sandy loam, but both produce good hardwood timber. An attempt was made to separate the data for these two soil types but no significant differences could be determined either in height of trees or volume growth. Therefore, no segregation was made.

Cutting Methods

The methods applied on the first eight cutting units were as follows:

1. *Clear cutting.* Everything merchantable, including saw-logs, mine timbers, tie cuts, and cordwood was cut and removed from the area.

2. *Twelve-inch diameter limit.* This was a clear cutting of all saw-log timber corresponding closely to a commercial operation where chemical wood is not utilized.

3. *Seventy per cent selection.* This heavy selection cutting left only a scattered stand of valuable trees. Emphasis was placed on spacing rather than condition of the residual trees.

4. *Overmature and defective.* All defective and overmature trees were removed, irrespective of size or spacing. The residual stand consisted only of exceptionally well formed, thrifty trees.

5. *Heavy improvement.* This was a moderately heavy cutting of the overmature and defective trees, irrespective of size or spacing.

6. *Group selection.* Groups of trees covering areas from one-tenth to one-half acre were clear cut and a very light salvage cut made in the remaining stand.

7. *Twenty-two inch diameter limit.* Only the very largest and most mature trees were removed. These were mostly over 22 inches in diameter. About one-fourth of the volume came from trees below that size, but only 5 per cent below 18 inches d.b.h.

[3]Veatch, J. O. and L. R. Schoenmann. Description of the soil types on the Upper Peninsula Experimental Forest. Manuscript report. 1929.

8. *Light improvement.* An extremely light cutting was made of mature and defective trees, regardless of diameter.

9. *Virgin.* This stand was retained in a virgin condition for comparison with the cutting plots.

In all of the cuttings, trees marked to be left but later broken in logging, were utilized and considered as trees cut. All material cut and not suitable for logs, tie cuts, or mine timbers, was worked up into chemical wood. The computations of stand, cut, and growth, however, are entirely on the basis of saw-timber.

Reproduction

To obtain satisfactory reproduction on the areas treated in these experiments, was not at all difficult; in fact, reproduction was adequate before cutting took place. A study of advance reproduction on a representative area indicated the presence of 24,700 seedlings per acre over one year old and less than one and one-half inches in diameter. Sugar maple made up 99 per cent of this total. Other species were much less common and the desirable yellow birch was practically absent in the advance reproduction. Some of the mixed species seeded-in after logging but sugar maple still makes up by far the greater part of the reproduction on all areas. Many of the smaller seedlings were cut off in the course of the logging operation but immediately came up as seedling-sprouts, a very desirable type of reproduction. All areas were found to be well stocked five years after logging no matter what degree of cutting was used.

Theoretically, the group-selection method in which definite openings were made, should have tended to encourage the seeding-in of yellow birch, an intolerant species which rarely becomes established in virgin stands. In this cutting method more yellow birch seedlings actually did appear than in other methods but this may have been due more to the presence of a greater supply of seed (there were more yellow birch seed trees present on this area than on some of the other cuttings) than to any intrinsic benefit from the method itself.

In the various lighter cuttings the advance reproduction of sugar maple made good growth following logging; in the heavier cuttings, although the advance growth of maple survived, there was some tendency for brush species to develop. A dense growth of herbaceous weeds such as fireweed and goldenrod, as well as the shrubs, elderberry, and raspberry came in quickly on much of the 12-inch diameter limit and clear-cut areas. The competition which they furnished was detrimental to the growth of tree species for a year or so but at the end of five years, sugar maple had become the dominant vegetation.

Red maple and aspen, which are so commonly found on commercially clear-cut areas throughout the Upper Peninsula, did not seed-in on the cutting areas under consideration, with the single exception of the 70 per cent selection method. On this particular area a combination of favorable weather and the presence of abundant seed blown in from a distance, brought about the establishment of many aspen seedlings. The lack of aspen and red maple reproduction on the clear-cut area where it would ordinarily be expected is perhaps due, not so much to the lack of a favorable seed bed and environment for these inferior species, as to the lack of seed trees in the immediate vicinity. The clear-cut area is only five acres in extent and is surrounded by fairly large bodies of lightly cut or virgin hardwood forest where sugar maple far outnumbers all other species. The fact that red maple seed trees were practically eliminated in all the cutting operations, no doubt, largely explains its absence in the reproduction.

The opinion has frequently been expressed that reproduction developing un-

der a selection system is apt to be crooked. No evidence of this was noticed in these cuttings, perhaps because of the fact that even light selective cuttings tend to be group-wise in character and the seedlings usually develop fairly freely in small openings.

Growth Following Cutting

The cut-over stands, on the basis of sample-plot measurements, responded remarkably well to the opening up of the forest by making an increase in volume, diameter, and even height growth. All trees even those in the virgin area, continued to grow somewhat in height. But height growth on trees over 18 or 20 inches in diameter does not add to merchantable volume in board feet since the tops of such trees have already split up into many large branches and a fixed merchantable height is developed. Additional height growth in the topmost branches, therefore, means little in the form of increased volume in board feet.

Diameter growth, on the other hand, is of utmost significance in selective logging and contributes directly to the volume of merchantable timber produced. The measurements showed that the diameter growth generally increased with the degree of cutting. This tendency was greatest in the smallest diameter classes (Table 1).

Volume growth was from 98 to 245 board feet per acre per year (Table 2) depending on the degree of cutting. In stands from which one-fourth to one-third of the original volume was removed, about 245 board feet per acre over and above losses was produced annually. Where half to two-thirds of the stand was cut, the growth amounted to about 160 board feet, but where 90 per cent was removed, the growth was less than 100 board feet per acre each year. These figures agree rather closely with previous growth data determined by increment studies made by Zon and Scholz[4] in stands "accidentally" logged selectively.

The net annual growth in the uncut forest was computed to be 191 board feet. Although this determination may appear to be contrary to the general belief that growth in uncut forests balances mortality, it should be kept in mind that this is a small tract. Mortality through windfall, decadence, etc., in a virgin forest is apt to be concentrated in certain localities and not evenly distributed. This is especially true for a period as short as five years. Moreover, there is no way of finding out how much invisible decay is taking place in a stand such as this. The principle that growth balances mortality, therefore, should be applied only to large forest tracts.

The problem of decay and cull, how-

Table 1
ANNUAL DIAMETER GROWTH BY SIZE GROUPS

Method of cutting	Diameter breast high			
	2-7 inches	8-14 inches	15 and up inches	Average inches
1. Clear cutting	.230	----	----	.230
2. 12-inch diameter limit	.260	.21	----	.250
3. 70 per cent selection	.160	.157	.152	.158
4. Overmature and defective	.181	.170	.132	.176
5. Heavy improvement	.182	.135	.129	.165
6. Group selection	.094	.100	.105	.098
7. 22-inch diameter limit	.111	.161	.161	.126
8. Light improvement	.123	.135	.153	.130
9. Virgin	.061	.105	.123	.079

[4]Zon, Raphael, and H. F. Scholz. How fast do northern hardwoods grow? Wis. Agr. Exp. Sta. Research Bull. 88. 1929.

ever, is not only limited to the virgin stands, but is also of significance in the determination of growth in stands selectively cut. In the growth calculations all volume in trees which were windthrown or which died from other causes was deducted even though in accessible areas many such trees could have been salvaged. No deductions, however, were made for cull. Although trees from virgin stands in Upper Michigan frequently contain 15 to 30 per cent cull, those left after selective cutting should contain considerably less defective material. But how much less no one can say on the basis of the information at hand. By careful marking it should be possible to eliminate the greater part, but not all, of the defective trees in the first cut. To cut them all would result in too drastic a cut.

Mortality After Cutting

Because some doubt had been expressed that mortality in northern hardwoods due to windfall and natural decadence might be so great after selective logging as to exceed the annual growth thus making such cutting entirely impracticable, a special study was made of this question.

Beginning in 1929, a complete (100 per cent) tally was made of all dead trees, not only on the sample plots but over the entire cutting areas as well, and on 50 acres of virgin forest. All trees that were dead at that time were clearly marked so that they would not be confused with trees which died subsequently. Each spring this procedure was repeated and the new cutting units added to the summary.

The average mortality on the basis of these records for all selective cuttings, in which less than two-thirds of the volume was removed, with the exception of the group-selection and 70 per cent selection methods, was found to be 29 board feet or less than one-half of one per cent of the residual stand. In the group-selection and 70 per cent cuttings the method used did not permit removal of many of the defective trees, and the annual loss was respectively 71 and 63 board feet per year. Even this was only a fraction of the loss on the virgin areas where the average annual mortality amounted to 140 board feet per acre per year or almost one per cent.

Considering all cuttings, over half the mortality was due to trees being broken by the wind; about one-third of the trees lost were uprooted, and less than one-fifth died standing. The breakage factor, therefore, is the chief one to be reckoned with. Since breakage took place on trees having weak spots and defects such as burls, it is apparent that this is a point deserving of careful attention in marking.

It is evident from the mortality study

Table 2

AVERAGE NET ANNUAL VOLUME GROWTH PER ACRE[1] FOR 5-YEAR PERIOD

Method of cutting	Per cent of saw-timber removed	Growth: In bd. ft.	Growth: In per cent	Basis (Area of sample plots in acres)
1. Clear cutting	100	0	0	2.0
2. 12-inch diameter limit	90	98	6.2	2.0
3. 70 per cent selection	68	110	2.1	4.0
4. Overmature and defective	62	160	3.1	2.0
5. Heavy improvement	46	163	2.2	2.0
6. Group selection	45	106	1.0	4.0
7. 22-inch diameter	29	245	2.2	4.0
8. Light improvement	24	235	2.2	1.0
9. Virgin	9	191	1.2	2.0

[1]Windfall and other losses deducted, but no deduction for cull. Board-foot volumes computed on basis of Scribner rule for all trees over 9.5 inches d.b.h.

and from the growth data presented that mortality, while always present, does not constitute a serious handicap to selective logging in the type of forest covered by this study. On the contrary, selective logging, if properly carried out, can be the means of decreasing mortality and increasing growth by taking out in the first cutting, trees that are most likely to succumb in the course of the next 15-20 years. For this reason such methods as the group-selection when applied to old-growth stands and others which do not allow the marker an opportunity to discriminate against poor trees are less effective than a single-tree selection. In young thrifty stands the group-selection method might possibly have more application.

Application of Results to Management

The determination of the degree of cutting to use in the management of any given tract of northern hardwood timber in the Lake States depends not only on the volume per acre and the condition of the stand, but also upon the ultimate aim in management. Assuming that sustained yield is desired, it will be necessary to postpone the second cut until the residual stand has replaced by growth the volume removed at the first cut.

This principle may be illustrated by considering two separate types of cuttings described in this paper. The overmature and defective cutting is an example of a silviculturally sound but fairly heavy cutting method where two-thirds of the volume was removed. The net growth was about 160 board feet per acre per year, which would require a cutting cycle of 50 to 55 years for replacement of the volume removed. On the other hand, the 22-inch diameter limit cutting, also good from the silvicultural standpoint, removed 29 per cent of the original volume. At the present growth rate of 245 board feet per acre per year, this volume would be replaced in about 20 years.

Such growth, in either case, could be obtained only through good working practice and would not be applicable to stands which have been "high-graded" for the better material or to stands where the cull trees have not been removed. The lighter the individual cuttings can be, based upon sound silvicultural practice, the greater will be the volume growth and the shorter the cutting cycle.

Summary

1. Growth following experimental selective cuttings in northern hardwoods in Marquette County, Mich., ranged from 160 to 245 board feet per acre per year (after deducting for mortality) where from one-third to two-thirds of the stand was left in good growing trees, but only 98 board feet per acre per year where 90 per cent of the volume was cut. This emphatically points out the necessity for leaving an adequate growing stock of thrifty trees in order to obtain the maximum growth in board feet.

2. Mortality, on the average, for selective cuttings of the single-tree type was 29 board feet per acre per year. It was two and one-half times greater on cuttings where spacing or a group arrangement was emphasized and insufficient attention given to removal of defective material. It was highest of all in the virgin forest. Selective logging can be made the means of decreasing loss through natural causes by judicious selection of defective and overmature trees. A single-tree selection which permits removal of defective and mature trees regardless of spacing, gave the best results.

3. Reproduction of sugar maple was abundant before cutting and made good growth after the stand was opened up. Few weed species appeared after logging except on the heavily cut areas.

TOOLS AND LABOR REQUIREMENTS FOR PRUNING LONGLEAF PINE

By HENRY BULL

Southern Forest Experiment Station

In order to produce a reasonable percentage of clear lumber on a short rotation in open stands of longleaf pine, artificial pruning often will be required. In the following article the author describes the efficiency of various tools, methods, costs, and the results of pruning open-grown, second-growth saplings, and small poles. Data are given which are useful in estimating pruning costs to be balanced against probable increases in the values of sawlogs or other products as a result of increasing the proportion of clear material.

IN fully stocked stands or in stands containing hardwoods, second-growth southern pines usually develop reasonably clear stems by natural pruning. In a large percentage of stands in the South, however, the dominant pines are relatively open-grown at early ages and remain in this uncrowded condition so long that when they reach sawlog size they have very short clear lengths. This is especially true of loblolly pine in old-field stands; but is also true of other southern pines and other conditions such as longleaf pine in poorly stocked stands on cut-over land. In the latter case, open-grown, second-growth longleaf pines are suitable usually only for naval stores. For almost any other use, but especially for sawlogs, poles, or piling, they leave much to be desired. For sawlogs, the spread in value between clear and knotty lumber is so great that a greatly increased profit from clear stems is unquestionable. For example, in recent years the difference in value between B and Better and No. 2 Common grades in southern pines, has averaged approximately $17 per thousand board feet. The outstanding difference between these grades is merely the number, size, character, and location of knots. For poles and piling, certain groupings of large limbs or stubs make a tree unmerchantable.

These facts indicate that artificial pruning in certain stands may well prove to be not only profitable but thoroughly practical. However, data on the efficiency of various tools and methods, costs, and results of pruning southern pines are lacking. The present study was undertaken to supply these data. Costs are given in terms of man-hours of labor from which actual costs can be readily computed for any given wage rate.

A preliminary test of nine different commercial hand pruning saws and a tree-trimmer in pruning loblolly pine served to narrow the field of tools suitable for more detailed tests. The tree-trimmer, mounted on a pole, was unsatisfactory because branches more than about 1¼ inches in diameter could not be cut and a small stub was always left. The four best hand pruning saws had relatively short (14-inch), narrow, curved blades with 5½ to 8 teeth per inch and open, pistol-grip handles. These saws were easy to start and manipulate, seldom stuck, and cut rapidly. They were used again in the present study and are discussed below. The other five hand pruning saws were generally hard to start and manipulate, sticking and "hanging up" occurring frequently. These were the larger saws (22- to 26-inch blades) with relatively broad, straight, or slightly curved blades, coarse teeth (less than 5 per inch) and handles very similar to that of the conventional carpenter's saw.

These saws were satisfactory only for very large branches, which occur infrequently on southern pines less than about 8 inches in diameter, the trees presumably most suitable for pruning.

Longleaf pine is a comparatively easy tree to prune. The branches typically occur singly or in small whorls with considerable space between each branch. Thus each branch may be readily sawed from a position at right angles to its length and flush with the bole. Longleaf pine branches also show no tendency whatever to strip the bark from the main stem below them when they break before having been cut entirely through. In these respects longleaf pine is essentially similar to loblolly pine, but is even easier to prune because of the absence or smaller number of very small branches in which the teeth of a saw are likely to stick or catch. Both longleaf and loblolly pines prune much easier than northern white pine, which is frequently pruned in the Northeast.

Field Work

A total of 1,195 limby, open-grown, second-growth longleaf pine saplings and small poles were pruned. The trees ranged from 2.6 to 8.5 inches d.b.h. and were mainly 15 to 30 years old. They are located on cut-over land on the McNeill division of the Harrison Experimental Forest in southern Mississippi, and are permanently numbered so that the effects of pruning on rate of growth may be studied. From the isolated positions of these trees and from observations of older trees that originally occupied similar positions, it seemed certain that natural pruning would not satisfactorily clear even the first 16-foot log by the time the trees reached sawlog size. To check on this point and on the rate of growth, 108 similar trees were numbered and left unpruned for later comparisons.

The pruned trees were pruned to various heights above ground as follows: 221 trees were pruned to 8 feet, 100 trees were pruned to 12 feet, 668 trees to 17 feet, and 206 trees to 25 feet. Pruning to 17 feet (one full 16-foot log above a stump) was tested in two steps, from 0 to 8 feet and then from 8 to 17 feet; and also in three steps, from 0 to 7 feet, then from 7 to 12 feet, and then from 12 to 17 feet. Eight different tools were used: an ordinary single-bitted ax, a light belt ax, 4 different commercial models of hand pruning saws, and 2 different commercial models of pole pruning saws. The hand saws were used from the ground and from 8-, 12-, and 20-foot ladders. The pole saws were used from the ground and from 8-, 12-, and 20-foot ladders. The axes were used only from the ground. The various pruning treatments (heights and tools) were distributed equally through three 2-inch diameter classes and over the entire area occupied by the numbered trees.

Although the men participated in the pruning, six men did most of it. Seven pruning sections were recognized, namely: 0-7, 0-8, 7-12, 8-12, 12-17, 8-17, and 17-25 feet above the ground. These sections were the smallest units for which detailed data were recorded. The following data pertinent to a study of methods and costs were recorded for each pruned section: (1) the man who pruned it; (2) the time to the nearest hundredth minute, taken with a stop watch; and (3) the basal diameter and condition (live or dead) of each limb removed.

Analysis of Data

For each section, the pruning time was correlated with tree diameter at breast height, number of branches cut, and average basal diameter of branches cut. For each section a multiple regression equation based on the data for all men and all tools combined was computed from which an alinement chart was made. The

residuals (or differences between actual and estimated times) were sorted by man and by tool and the mean residual for each man-tool class was computed. The residuals were then studied by means of analysis of variance to determine the significance of observed differences. The field work was planned with this analysis in mind, and the analysis would have been comparatively easy if the original plan could have been followed. However, due to many changes in the working plan caused by unforeseen shifts in the available emergency labor, the analysis actually became very complicated. Instead of equal numbers of observations in each man-tool class, the numbers were not only unequal for any one pruning section but the inequalities were also different for each section. Despite these inequalities, however, each man and each tool covered practically the same range of tree sizes and number and size of branches cut. Satisfactory expressions of the standard errors of the average times given in Table 1 were not obtained.

The multiple correlation that constituted the first part of the analysis were not carried beyond linear relationships even though most of them gave evidence of slight or pronounced curvilinearity. The reasons for this were: (1) that the correlations were merely a means of accounting for variation introduced by differences in the amount and difficulty of pruning required so that men and tools could be compared on equivalent bases and were not intended to provide estimates of pruning time for general use; (2) that errors of estimate due to nonintroduction of curvilinearity would presumably affect all man-tool classes in the same way and would not bias the analysis.

Results of the Study

METHODS AND TOOLS

Ax and Belt Ax vs. Pruning Saw.—Contrary to expectations, the ax and belt ax were not faster to use than any of the hand pruning saws. One of the hand pruning saws (a curved California-type saw with a very stiff, narrow blade and 8

Table 1

AVERAGE TIME REQUIRED TO PRUNE OPEN-GROWN LONGLEAF PINES, SUMMARIZED BY THE DIAMETER OF THE TREE AND BY THE SECTION PRUNED

PART A: FOR ALL MEN AND ALL TOOLS TESTED

	Height above ground of section pruned, in feet								
D.b.h.	0-7	0-8	7-12	8-12	12-17	8-17	17-25	0-7 plus 7-12 plus 12-17	0-8 plus 8-17
Inches	*Average time in man-hours*								
3	.006	.008	.014	.009	.023	.033	.034	.043	.041
4	.006	.008	.019	.014	.027	.042	.042	.052	.050
5	.006	.009	.024	.018	.033	.054	.066	.063	.063
6	.007	.010	.028	.022	.043	.067	.100	.078	.077
7	.007	.010	.032	.026	.058	.079	.134	.097	.089
8	.008	.010	.036	.028	.076	.092	.172	.120	.102
PART B: FOR THE FASTEST MEN WITH THE FASTEST TOOLS									
3	.005	.007	.009	.007	.014	.020	.029	.028	.027
4	.005	.007	.012	.011	.016	.025	.035	.033	.032
5	.006	.008	.015	.014	.020	.033	.055	.041	.041
6	.006	.008	.018	.018	.026	.041	.083	.050	.049
7	.006	.008	.020	.021	.034	.048	.112	.060	.056
8	.006	.009	.023	.023	.044	.056	.143	.073	.065

teeth per inch) was significantly faster to use on the 0- to 8-foot section than the ax, belt ax, and 3 other hand pruning saws. Two factors contributed largely to this result: (1) the cuts were required to be reasonably smooth and flush with the bole of the tree. For this reason the men almost invariably had to take several extra strokes with the axes; and (2) skillful use of an ax or belt ax requires far more practice than is needed to do good work with a saw, and the men had no opportunity to become really proficient before they were timed. When carefully and skillfully used, the axes did neat and satisfactory work. Considering, however, that they are no faster than hand saws, are much less safe to use, and are much more likely to be used hastily and carelessly, the axes were considered much less satisfactory than hand pruning saws.

Hand Pruning Saws.—The same saw that was fastest to use on the 0- to 8-foot section was faster than 2 other saws and equally as fast as a third saw when used on the 0- to 7-foot section. The latter saw had a very stiff blade with 5½ teeth per inch, a less curved blade, and a longer handle than the saw described above as fastest on the 0- to 8-foot section. The two better saws were about 20 per cent faster than the poorest saw. The poorest saw had a slightly curved, rather flexible blade with 8 rather short teeth per inch. Its inferiority was evidently due to the flexibility of the blade and to the shortness and obtuseness of the teeth. The two better saws differed considerably in number of teeth per inch; but both had very stiff blades and very acute, relatively long teeth. The saw with 8 teeth per inch cut on both strokes, but the saw with 5½ teeth per inch cut only on the draw or pull stroke. In working from the ground this difference seemed to have no consistent significant effect. When used from a ladder, however, the finer-toothed saw cutting on both strokes generally proved significantly faster. The quality of the work was equally satisfactory for all 4 hand saws that were tested.

Pole Saw vs. Hand Saw and Ladder.—The better of the two pole saws tested was significantly faster on the 8- to 17-foot and 12- to 17-foot sections than the best of the hand saws used from a ladder, but not significantly faster on the 7- to 12-foot and 17- to 25-foot sections. The better pole saw was about 20 per cent faster on the 8- to 17-foot section and about 12 per cent faster on the 12- to 17-foot section than the best hand saw used from a ladder. The better pole saw had a stiff 16-inch blade rigidly attached to the pole, 7 teeth per inch, and cut only on the draw stroke. The other pole saw had a rather flexible blade that could not be attached absolutely rigidly to the pole because of the method used to permit adjustment of the angle of the blade. These characteristics made it very difficult and unsatisfactory to use.

The quality of the work done by the better pole saw was fully as good as that done by the best hand saws. At first, none of the men liked the pole saw because it was very tiring and awkward to use. Soon, however, they acquired the knack of using it, and then most of the men preferred it to the hand-saw-and-ladder method. If not used too steadily by one man, the pole saw is not unduly fatiguing. Usually the work can be so arranged that a man is not required to use a pole saw exclusively for long periods. Some men, however, even after much practice, apparently are unable to use a pole saw skillfully. These men usually do much better with a hand saw and ladder.

A final but very important consideration in comparing the two methods is the size of the trees. Unless the tree is at least 5 inches d.b.h., pruning from a ladder is difficult, dangerous, and usually impossible. For trees about 8 inches

or larger d.b.h. and especially trees with large limbs, the ladder method is likely to be not only somewhat faster but its results are better. For trees between 5 and 8 inches, either method is satisfactory. Whichever better suits the workmen, may be considered the more efficient method. Judged by these tests, a good man with a pole saw can prune medium-sized trees somewhat faster than an equally good man with a hand saw and ladder; but it is probably somewhat easier to find a good man for the latter method than for the pole saw.

The two preceding paragraphs apply only to pruning up to 17 feet. In pruning from 17 to 25 feet, the better pole saw attached to a 20-foot, jointed wooden handle was extremely awkward to use and required great care both in raising and in lowering it. Although the observed times showed no significant differences between the pole saw and the hand saw used from a 20-foot ladder, the pole saw was considered unsatisfactory at this height. A much more rigid handle, however, counterweighted at the butt to compensate for top-heaviness, might make this tool satisfactory. Once in position, the 20-foot pole saw was not unduly difficult to use, and the work was of satisfactory quality. The strain of holding it up after cutting each branch, however, and the great care constantly required to prevent snapping the pole, made the 20-foot pole saw not only undesirable for practical use but probably slower than the ladder method on the basis of total elapsed working time in a stand.

LABOR REQUIREMENTS

Efficiency of Labor.—Six C.C.C. and W.P.A. workers did almost all of the pruning. Rated by their speed and quality of their work, these men differed greatly in efficiency. In addition to great differences when the same tool was used, some men did their best work with tools that other men used most poorly. Because of these large variations, average labor requirements of pruning and the comparison of tools are necessarily subject to large probable errors; and for this reason, when applied to any particular crew of workers may be misleading or unreliable. The comparative labor requirements by diameter classes and by sections pruned, however, are considered reliable. Since no tool or method is likely to be best for all men, the tools and methods used should be suited to the men who must use them. The results given in this paper will serve as a guide to this end.

Other Factors Affecting Labor Requirements.—Eliminating the important variations between men and between tools, the position and length of the section pruned and the diameter at breast height of the tree directly affect labor requirements; and for this reason, are practicable factors that must be taken into account in making estimates. Other factors, such as the number and the average diameter of the branches removed, are also definitely correlated with labor requirements; but are not suitable for general use in making estimates.

Average Labor Requirements in Man-hours.—Average labor requirements in man-hours are tabulated in Table 1 according to the section pruned and to the d.b.h. of the trees. In part A, the average times are listed for all men and all tools. In part B, the average times are listed for the fastest men with the fastest tools. The times in part B range from 16 to 41 per cent less than the times in part A. The pruning times in minutes for each section were read from smooth curves and converted to man-hours. No attempt was made to harmonize the curves for the different sections. It is thought that even the times in part B may often be excelled by skillful and experienced men, since the figures represent merely the best 1 or 2

of only 6 men actually timed.

Data from these tables are useful in estimating pruning costs to be balanced against possible or probable increases in the values of sawlogs or other products as a result of increasing the proportion of clear material. The data in Table 1 represent basic, effective working times. To estimate approximate elapsed working time (including walking from tree to tree, resting, etc.) for low pruning or for high pruning with pole saws, 50 per cent should be added to the time shown in the table. If a ladder is used, 60 per cent should be added. These are very rough figures for converting effective working time to elapsed working time, since they are based largely on very limited experience in the present study. Estimates of elapsed working time are, therefore, admittedly subject to a large probable error. As with the effective working times shown in the table, however, comparisons of estimated elapsed working times for different tree diameters and sections pruned are considered reliable and subject to a comparatively small error. The use of part B of the table may be illustrated as follows: to find the approximate time needed to prune, in 2 operations, 100 5-inch trees per acre to a height of 17 feet, multiply 0.041 man-hour by 100 and add 50 per cent, which gives a total of 4.1+0.50(4.1) or 6.15 man-hours.

Soil Conservation Service Planting

About 175 million trees and shrubs will be planted during 1937 by the Soil Conservation Service as part of its soil erosion control program. During 1936 the S.C.S. planted 130 million trees, mostly hardwoods, on project areas throughout the country. The 1937 plantings will bring the total number of trees and shrubs planted for erosion control by the S.C.S. to 700 million in a little more than four years.

THE PERMANENT FIXATION OF SAND DUNES IN MICHIGAN

By R. F. KROODSMA

Resettlement Administration

Sifting sands occur in many parts of the United States and often cause considerable damage. The author has considerable experience in sand-dune fixation in Michigan and describes in detail the methods and costs of fixing moving sand dunes.

SAND dunes may be defined as hills or ridges of loose, drifting sand, originally heaped up by winds. They are commonly found near a seashore or the shore of a lake. These formations occur quite generally on all of the continents. In America they are found along the Pacific Coast, the Atlantic seaboard and in the region of the Great Lakes. Inland dunes occur in various parts of the United States. It is estimated that in Michigan there are in the neighborhood of a half-million acres of sand dunes lying in irregular belts along the eastern coast of Lake Michigan, the northern shore of Lake Michigan in the upper peninsula, the southern shore of Lake Superior in the upper peninsula, and the western shore of Lake Huron, particularly in the northeastern part of the lower peninsula. The belt of dunes in the western part of the state is by far the most important both from the standpoint of extent and control. It starts from the Indiana line and extends intermittently for a distance of some 300 miles north to the Straits of Mackinac.

Some of the dunes have an elevation of 20 or 50 feet, while the largest rise to heights of 150 feet and over.[1] These vast hills are composed of pure sand-quartz, and a small per cent of other rock minerals. Drillings reveal that this formation extends to a depth of 200 feet or more below ground level. The sand particles are exceedingly small, appearing under the microscope as smooth, rounded or globular grains.[2] Their origin was the bottom of the lake. For ages the fine sand was rolled about by the waves until all of the sharp edges and corners were worn smooth. Severe storm-wave action continually deposited small drifts along the shore line and as these became dried out, the prevailing winds rolled the sand particles along the surface of the ground farther inland, where a little vegetation caught and held the sand causing the formation of drifts and mounds. In this manner, there were formed finally huge sand hills or dunes. It is probable that the dunes were at one time conquered by the forest as many of them still maintain tree vegetation. To the layman this type is known as a fixed or stationary dune.

If the vegetative crust of a fixed dune becomes disturbed or broken either as the result of fire, lumbering operation, or wagon tracks, wind erosion may start and before long the underlying sand is carried away and deposited farther on in drifts. This is the beginning of a traveling dune. The windward side of such a dune presents a gentle slope, increasing slightly as the summit is reached and breaking over sharply into a steep decline. The steep slope is called the leeward side of the dune.

A fixed dune is an ecologist's paradise. Here may be found almost every variety of plant, shrub, and tree growth native to

[1]Mount Tom in Indiana has an altitude of 190 feet.

[2]The consistency, size, and other physical features of sand particles vary in different sections of the country.

the state of Michigan. On apparently sterile sand one does not ordinarily expect to see ash, walnut, butternut, beech maple, basswood, and tulip poplar; yet they thrive side by side with the oaks, hickory, birch, aspen, pine, hemlock, spruce, and cedar. Or is the quality of growth what one might expect to find on a poor quality site. The pine stumps which still remain from the earlier logging operations bear mute witness to very good timber growth.

To a person unfamiliar with moving sand dunes, it is hard to realize their magnitude or the grim wave-like action with which they advance, burying everything in their path.[3] Examples of their destructive action are numerous.

Old geographies of Michigan show that a once thriving sawmill town was located at the mouth of the Kalamazoo River near the present town of Saugatuck. Singapore was completely buried by a sand wave and became known as the Pompeii of America. Today it is being slowly uncovered as the wave moves on. Several miles to the south of this dune is another sand wave which is slowly, but surely, burying a beautiful lake together with its surrounding farmlands and orchards.

In Muskegon County, 30 miles to the north, a cherry orchard has been nearly buried. The trees still blossom and one can walk through the tops at cherry time and pick fruit. To the uninitiated, the tree tops sticking above the sand appear to be some new variety of shrub cherry. In other sections of the state, highways are being covered, harbors are filling up and resort cottages are threatened with burial.

Numerous attempts have been made i the past to stop the economic loss cause by the traveling dunes. Sanford reports that in 1902-3 the federal governmen made plantings in various dune areas o Michigan. In 1913, the Michigan Stat College made a small experiment in th extreme southwestern part of the state In addition, several attempts were als made by private owners. The governmen plantings were only partially successfu largely because there was no follow-u work. Private undertakings failed becaus of lack of funds.

In 1930 the writer, then extension fo ester for the state of Michigan, wa called upon to aid in two very bad blo areas known respectively as the Michi linda dune, Muskegon County and Ol Bald Head, Allegan County. As the re sult of work done on these two areas technique was developed which was en tirely successful in controlling shiftin sands. The steps are explained in mor or less detail with the hope that the may be of help in similar situations else where in the United States. There ar four steps as follows:

1. Distribution of dead cover to hol the sand.
2. Planting of hardwoods and cutting
3. Planting of conifers.
4. Sowing of rye.

The erection of artificial barriers suc as various types of fences is just a mak shift. They may serve to hold the san temporarily but should never be relie upon to effect a permanent cure. Th planting of grasses or other vegetatio without additional protection is futile.[5]

There is only one way to curb th

[3]Dunes in Michigan move at the rate of 18 inches to 2 feet per year.

[4]Sanford, F. H. Michigan's shifting sands. Mich. Agri. Exp. Sta. Bull. 79:916 (obsolete).

[5]Beach grass, *Ammophila arenaria,* which is found growing on most sand areas is often re ommended for planting to hold sand. This grass, however, in the work in Michigan, was of ve little value in the actual control of a dune. It grows naturally where the sand is being deposite —never where it is being picked up and carried away by the wind. The grass is not much of barrier against wind, but its roots hold sand. Its main value is to help hold sand which is bein deposited on the lee side of a dune. It is, without doubt, the best natural sand binder know but trees planted in its protection by the writer in experiments over a period of 5 years were total loss.

movement of sand. It is to spread inert material over the surface on which planting is contemplated. Various substances, such as cornstalks, hay, brush, or reeds may be used as a dead cover; but brush is by far the best material for this purpose. Inasmuch as the principal object of the cover is to hold the sand until tree growth is established, it is essential to select material that is not subject to decay for at least 2 or 3 years. The planting of the trees and the spreading of brush may be interchanged as it is often more convenient to spread the brush after the trees have been planted. A list of trees used for planting together with notes on their desirability follows:

Hardwoods

1. Black locust (*Robinia pseudoacacia*) is one of the best trees for planting on sand dunes. It makes a luxuriant root growth, withstands drought, makes a vigorous top growth within 3 years and bears seed after 2 years. In Michigan it is subject to borer injury, but it accomplishes the desired results in spite of this handicap.

2. Carolina poplar or cottonwood (*Populus deltoides*) is a very good tree for sand-dune planting. It makes good root growth and fast top growth and is especially valuable because it may be propagated by cuttings made just previous to the time of planting.[6] It makes a good nurse tree for pines.

3. Willow (*Salix* sp.) produces a rather low shrubby growth, but is valuable because its roots stool out well and are very effective in holding sand. It is also valuable because it is so easily propagated from cuttings.

4. Honey locust (*Gleditsia triacanthos*) is a poor tree for sand-dune control. It barely maintains itself under such conditions.

5. Largetooth aspen (*Populus grandidentata*) together with the aspen and lombardy poplar, may be used, but are not quite so vigorous as the cottonwood. They are easily established by means of cuttings.

6. White poplar or abele (*Populus alba*) theoretically should be an ideal tree for sand-dune planting because of its vigorous root-sprouting habit. It is difficult to grow from fresh cuttings, however, and of several hundred planted by the writer, only a very few sprouted and grew. It is believed that this trees has possibilities and that seedlings or a change in the technique of handling cuttings might prove more successful in securing establishment.

7. Black walnut (*Juglans nigra*). The seed of this trees as well as of the butternut were planted on one area. The nuts germinated and grew, but produced a small top in comparison with other trees. Black walnut may be of value as a final crop tree, but should not be considered important from the standpoint of sand-dune control.

8. Sumac (*Rhus hirta*) thrives in sand but the top is not bushy. It is inferior to some of the other trees.

Conifers

1. Ponderosa pine (*Pinus ponderosa*) has proved to be one of the best trees for growth on sand dunes in Michigan. It produces good root growth and a dense vigorous top. So far it has made the best growth of any conifer on sand. The most critical period for this tree is the first year after planting. It is probably more subject to drought injury the first year than some other trees.

2. Scotch pine (*P. sylvestris*) withstands drought well and makes a vigorous root and top growth in sand. It produces a tree of poor form, but serves the

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[6]Seedlings are fully as desirable, but usually less available.

purpose of holding sand and making a wind barrier. Scotch pine from "pedigreed" selected seed may not only prove to be superior in timber form but also more resistant to disease and insect attack than stock from seed now commonly planted. Other things being equal, exotics are to be avoided until their worth has been proved.

3. Pitch pine (*P. rigida*) has survived transplanting and is making a vigorous growth. It may eventually prove to be a good tree but has not been used long enough in the state to justify recommending it.

4. Norway pine (*P. resinosa*) does fairly well in sand. It is fairly resistant to drought and produces a straight tree. It makes a good wind barrier.

5. Northern white pine (*P. strobus*) is not so resistant to drought as some of the other pines. When it once becomes established, it produces both good roots and top growth. It makes an excellent wind barrier.

6. Jack pine (*P. banksiana*) grows vigorously for a few years, resists drought, but has rather thin and open foliage.[7]

7. Scrub pine (*P. virginiana*) has made good growth on Michigan sand dunes. It is hardy, resists drought, and compares favorably with native jack pine.

The best hardwoods for sand-dune fixation are undoubtedly the black locust, the cottonwood or Carolina poplar and the aspen followed by the willows, either the cultivated basket variety or native. Among the conifers, the ponderosa pine, Scotch pine, Norway pine, and jack pine are perhaps best. Pitch pine has not been established long enough to warrant final judgment, but it apparently has possibilities.

Procedure for Planting

It is essential to attack a sand dune from the windward side, therefore, if the entire surface cannot be covered at one time, the start must be made at the windward edge. The remainder of the area can be planted as funds and time allow, proceeding toward the lee side of the dune. Before any work is begun, a careful study should first be made to determine the prevailing direction of air currents and sand movement.

Fig. 1.—Bundles of brush stacked at foot of dune. Note pile of bundles in exact center. These will be snaked to the top by pulley. The white sand gives the appearance of snow.

[7]Jack pine which has been planted on some of the Indiana dunes has done exceptionally well.

All varieties of trees are easily planted by one-man crews using the slit method. The black locust should not be over 1-0 stock and seedlings at least 18 to 24 inches in height are preferable. Stock which is too small is likely to be either blown out or buried in spite of the protective covering. All seedlings should be carried in a pail having 3 or 4 inches of water and planted by making a slit in the sand with a round-pointed shovel, inserting a seedling, and tamping with the feet or the planting tool. One man should plant from 1,000 to 1,500 trees per 10-hour day.

Cuttings of willow and poplar should be made before buds start and just previous to time of planting. They should be taken from the last year's growth and planted within 3 or 4 days after being cut. A good cutting should be from ½ to ¾ inches in diameter at the butt end, and from 15 to 18 inches in length.[8]

Cuttings are set in the same manner as described for locust seedlings, i.e., the slit method. Even though the sand may appear loose, it is not advisable to push them into place because this tears the tender bark at the end thus preventing callusing and inducing decay. An 18-inch cutting should be planted to allow for a top, 6-8 inches above ground.[9]

Spring planting is recommended for all species. The black locust, poplars, and willows may be planted in mixture, keeping them in separate rows and staggering the rows. A 5 x 5 foot spacing gives good results. In planting hardwoods, sufficient space must be left for conifers which are to be interplanted later, preferably among the poplars and willows. If interplanted with locust, it will be necessary to release the pine before the locusts become too large. The pines may be set fairly close to the hardwoods, the object being to have the latter

Fig. 2.—Saugatuck dune looking down the slope and showing brush, black locust, and cuttings.

[8]Willow "cuttings" 4-10 inches in diameter and 6 feet long are still alive on the Saugatuck area after five years. In Ottawa county a cottonwood branch from which cuttings had been taken was discarded. It became covered with sand and sent up sprouts along the entire length.

[9]Cuttings made in the fall will callus if properly heeled in over winter and may be used in place of fresh cuttings.

act as a protection until the pines become established. The stock used should be either 2-1 or 3-0 and under this protection should become well established, eventually forming the main crop.

Either before or immediately after planting the area it will be necessary to spread brush. This brush may consist of small trees, or of branches trimmed from larger trees. Care must be taken, of course, not to injure the trees in securing brush nor to take small trees from areas where they can not be spared. Very often weed species such as soft maple, poplar, birch, tag alder, blue beech, or ironwood[10] are available. Brush which is 1 to 3 inches in diameter at the butt and from 12 to 15 feet long has proved to be most satisfactory. One side should be trimmed so that it will lie reasonably close to the ground. This trimming should preferably be done after the brush has been hauled to the problem area so that the small trimmings can be utilized. As to the species of brush which should be used, it is advisable, where possible, to select a wood which is fairly durable such as oak, elm, ash, maple, ironwood, or blue beech. Less durable species will no doubt have to be replaced. Tag alder used on the Saugatuck area in Michigan was replaced after 3 years. Oak brush used on another area is still in good condition after 6 years.

Several methods are used in hauling brush. Where a large crew of men is available such as C.C.C. camps, the brush may be quickly loaded by hand, piece by piece, on either a 2-ton truck or farm wagon. Where a smaller crew is available it was found to be more efficient to tie the brush, as cut, into bundles averaging 12 to 18 inches in diameter, using bale wire or other fine wire for binding. The bundles were tied at the butts and also at the center. This method of handling has several advantages:

1. The brush is handled more quickly and easily.
2. Larger loads can be piled on the truck or wagon.
3. If it is necessary to pull the brush up the side of a dune, as was the case at Saugatuck, bundles simplify fastening brush together and save expense.
4. Bundles readily lend themselves to distribution by means of a horse.
5. A more even distribution can be obtained than by scattering wagon loads.

For sand areas which are fairly level and easily accessible by truck or wagon it will probably be cheaper to haul the brush without tying it into bundles. It will also be cheaper to distribute it by a crew of men, rather than by horse.

After the bundles have been distributed the wires should be cut and the brush laid at right angles to the prevailing winds. Spacing is very important. It is poor policy to economize on brush by placing it too far apart. It must be spaced close enough so that air currents will not have an opportunity to carry sand particles. The distance of spacing will depend upon the character of the brush used and the amount of side branches. The pieces should be so laid that the side branches touch. It is a good idea to reverse butts and tops because fewer side branches are found at the butts. More or less bare poles will need to be 6 to 8 inches apart. Care should be taken to overlap the ends of the brush pieces, thus preventing any open lanes. Any brush which decays or becomes covered before the growth is established must be replaced.

Many plants and weeds will thrive in sand, provided it is stabilized. After the trees have been planted and brush laid it is surprising to note the amount of native vegetation which volunteers. This growth is most desirable because the process of building a new crust and a layer of dark colored soil is a slow one.

[10]Species included as weed trees vary according to locality.

It is possible to help nature along by planting rye. This is the final step in the control of sand and has been used with good success in Michigan. Rye should be sowed at the rate of two to three pecks per acre, in the fall, following the planting of trees. It is sowed broadcast throughout the brush area and germinates the same fall attaining a growth of 5 or 6 inches before freezing weather sets in. This protection during the winter months is of inestimable value, helping to catch snow and preventing sand movement, which, on top of a frozen crust, is often more severe than during the summer months. The rye lasts but one growing season, therefore the planting should be repeated for several years.

Costs

The costs of sand-dune control will vary in different localities, depending upon several factors such as accessibility of the dune, proximity of available brush, and cost of planting stock. The following costs per acre, based on a man-day of 8 hours, should apply to an average dune which does not offer unusual difficulties.

LABOR (MAN-DAYS)		OTHER COSTS	
Planting of 2,000 trees and cuttings	2	1,000 trees	\$2 to \$4
Making cuttings	¼	3 pecks rye	.50
Cutting and hauling brush	3½		
Spreading brush	¼		
Sowing rye	⅛		
Totals	6⅛		\$2.50—\$4.50

The total cost for treating the Saugatuck dune, an area of 5 acres, was \$650. From four to ten men were employed cutting, bundling, hauling, spreading brush, and planting trees. Costs were unusual on this area because of its inaccessibility. One team and one truck hire are included in these costs as well as the construction of a stairway consisting of seven flights of steps and seven rests or landings.

Areas which have been handled in the manner described above, have given gratifying results. The Saugatuck dune which had been a source of expense and trouble for more than 50 years, was completely brought under control by the end of the first growing season. An examination of the area on July 4, 1936, six years after planting, showed a good survival of all species planted with the exception of honey locust. Black locust was 15 to 18 feet high, growing vigorously and beginning to reproduce naturally.

The pines which were interplanted with the poplar and willow cuttings showed good survival with ponderosa, Scotch, pitch, Norway, and northern white pines doing the best in the order named. Rye which was sown the first fall had disappeared but native grasses and weeds were all seeding in and helping to form a new crust. The tag alder brush which had been used for a dead cover was partially replaced after 3 years. The cover now on the area will probably last until tree growth becomes large enough to hold its own.

Sand areas in Michigan constitute a real problem but under proper handling there is no reason why the very worst dunes cannot be brought under control and again be made to produce valuable tree crops.

A FOREST PROTECTION MANUAL FOR THE NORTHEAST
AN EXPERIMENT IN COOPERATION

By HENRY I. BALDWIN

New Hampshire Forest and Recreation Department

THE cooperative movement has led to the formation of consumer-cooperatives and producer-cooperatives. The latter have been found effective aids in solving marketing problems of farm woodlots and scattered small timber lots. There is no reason, however, why cooperation in forestry should be limited to the marketing of products. The purpose of a cooperative is to furnish some service or goods at a lower cost per unit than individuals singly could command. Quantity purchasing or selling is the essence of cooperation. Forest administration and management can profit from the cooperative idea as an accessory to cooperative marketing. Several groups of this kind have been formed in recent years. Forestry education, extension and propaganda is perhaps an even less proven field for cooperatives; yet the savings to be made both by producers and consumers are possibly even greater than in the case of more tangible products. The JOURNAL OF FORESTRY, and all similar organs of professional societies are usually true cooperatives, publishing papers at presumably less cost than individuals could do separately. The question might be raised why institutions which issue separate bulletins might not better pay the Society to print them in the JOURNAL as extra pages. This doubtless would be cheaper, and would be a further service of the JOURNAL to the members of the Society. The following paragraphs describe a specific attempt at cooperation in publication in a diverse group not organized in any one society.

THE PROBLEM

Disturbances of the "balance of nature" in the forests of the northeastern United States and Canada have been followed by an extraordinary number of injurious influences: insects, fungi, grazing and gnawing animals, fire, weather injury, physiological troubles and damage caused by other agencies. Many individual pests have occurred in outbreaks of startling proportions and the introduction of foreign pests, unrestrained by their natural biological controls, has led to enormous losses. The control of these various sources of damage has been undertaken by the various federal, state, and private organizations. With that we are not concerned. The desire on the part of foresters and laymen for information on the methods of control of the various enemies of trees is natural. It has been met by many excellent books, bulletins, and leaflets, issued by a large number of organizations. All these serve their purpose well, but there is often much duplication of effort, and consequent waste of funds.

The area included in New England, New York, and the southeastern parts of Canada has many forest problems in common and many of the same forest pests. In this area there are a score of agencies often issuing identical material on the control of various pests. Some organizations spend several hundred dollars on a single publication. The edition is soon exhausted or some part of the material becomes obsolete because of additional research, and a new publication is issued at further large expense. There are also in this area many experts who are specialists in some one species of insect or fungus, and would presumably be better able to write its control than others; but these specialists, with few exceptions, are at the disposal of their own institutions only.

It seemed obvious that if these resources of money and brains could be in some way pooled (a) great economies in

time and money and (b) superior presentation of the latest and most authoritative information, would be possible. There are, however, many obstacles: some organizations are limited in expenditure of funds to their own state; printing must be done only by their own state printer; publications cannot be distributed under frank unless published under the Land Grant College Act; authors cannot prepare manuscripts without the approval of superiors and editors in Washington, etc.

History of the Project

Nevertheless the advantages of cooperation seemed great enough to warrant an attempt at surmounting these and other obstacles. The N. H. Forestry Commission accordingly determined to make the experiment and in November 1935 proposals were made to a number of agencies. The response was so enthusiastic that further action was taken, and on February 1, 1936 a communication was sent out in the form of a mimeograph giving the results of the November questionnaire, and outlining the objectives of the plan. A sample leaflet, illustrating the type of publication suggested, was printed and sent to the cooperators. A canvass was then made of all the organizations on March 15, to find what 10 pests should be covered, and on April 8, a report was made of this vote and organizations invited to select subjects which each would cover. All subjects had been assigned by May, but unavoidable delay occurred in getting the final copy to the printer, so that the first 10 leaflets were not printed before early fall. Early in August the first advance leaflet for the next series was mimeographed and sent to the cooperators for criticism. On December 7, cooperators were sent a list of the second 10 subjects chosen by original vote, and asked whether they favored a continuation of the project. The response has been favorable to the publication of a second series in the spring of 1937.

A number of methods of printing and printers were investigated and it was decided to accept the offer of the Massachusetts Forest and Park Association to do the printing, since this organization had long experience in publishing similar bulletins. The first series was issued in an edition of 8,000 of each leaflet. A limited supply of the first series can still be obtained from the publishers, or from any of the cooperators. The first leaflets have not been perfect, and probably have not met fully the ideal of the cooperators. Improvement is expected, and revision as new information warrants.

Description of the Publications

The purpose of the publications is to make available to the cooperating agencies at low cost a series of leaflets, giving in clear, concise language the essential facts on identification and control of diseases, insects and other injuries to forest trees. The leaflets are intended for at least three educational uses: (1) identification of the injury caused by a given organism; (2) identification of the causal organism and its relation to the observed injury; (3) instructions for control both on individual shade trees and under forest conditions with emphasis on the importance of and need for control. Arrangement of subject matter follows a rather definite and uniform outline. This rigid framework is necessary so that the reader may find items in the same order in each leaflet, and so that authors will not exceed the scope of the leaflets. The standard outline proposed is as follows:

Outline for Forest Protection Manual Leaflets

The following standard form is suggested as essential to uniformity in treatment. More or fewer headings may be included in unusual cases, depending upon the requirements of each subject. The purpose of these leaflets is a *brief* accurate description of each tree trouble, giving the important information needed for:

(a) Identification of what caused the injury.

(b) Identification of the causal organism, and its relation to the observed injury.

(c) Control.

1. *Name.*—Approved common name, followed by scientific name and authority in (). Synonyms, both common and scientific, may be given in a footnote.

2. *Author of Ms.*, his title and official connection.

3. *History and Distribution.*—Very brief. May be omitted entirely in some cases.

4. *Host Trees.*—Common and scientific names. May be tabulated, but preferred species and those rarely or slightly attacked should be indicated.

5. *Symptoms of Damage.*—How to detect presence of the pest, and how to tell what agency caused the damage. This is placed before the description of the causal organism, because in most cases the damage will be more noticeable than the pest causing it.

6. *Cause.*—Description of the insect or fungus.

(a) How to identify it. Avoid scientific terms where others will do. e. g. Most readers know what larvae are, but "instar" may baffle them.

7. *Life History* (as brief as possible).

8. *Means and Rate of Spread. Importance of Control.*

9. *Control.*—This is the important part of the leaflet. If no control is known it should be so stated. New work is constantly in progress; proven methods should be given first, new and promising, but untried, so designated.

Separate headings for:

(a) Under extensive forest conditions.

(b) Individual shade trees.

In recommending sprays, etc., always give formulae for mixing.

10. *References.*—One or two recent more complete descriptions in English, either bulletins or journal articles. For those who want to find more complete description.

Illustrations.—A total of not over one full page of a 4-page folder should be devoted to illustrations. Each should be carefully labeled. Photographs or line drawings can be used. Existing cuts (plates or blocks) should be included whenever possible, since expense of making new reproductions may make it impossible to include many excellent illustrations. (Captions to accompany each illustration should bear acknowledgment for use of illustration in each case.) All cuts, photographs, etc., should bear the name of the sender to insure return.

Length of Text.—It is believed 500 to 1,000 words (2-4 pages of double-space typewriting) will be adequate to include the most important matters. Manuscript should be separated into paragraphs with heading for each as suggested by the outline.

Format.—Leaflets will be 6"x9". Text may begin on outside cover page. The names of all organizations cooperating in the project will appear in small type on the cover. The subject of the leaflets will appear in large, bold-faced type. The number of each leaflet will appear on each page. The year and month of publication will appear at the bottom of the first page. Each leaflet may be perforated on the left side to fit a binder.

The majority of the cooperators favored a series of separate leaflets, one for each pest, rather than a single bulletin. The expense of distribution for a single publication is high, and there is a good deal of waste in using them to answer inquiries about one pest only, with which most inquiries are concerned. Some felt that the educational value of a single bulletin was superior. The advantages of both are secured by perforating the leaflets for loose-leaf binding. These bound manuals can be furnished officials and employees of each organization, such as fire wardens, tree wardens, rangers, C.C.C. foremen, blister rust agents, etc. The other bound copies can be sold to the public at cost or slightly more; separate

leaflets, costing only a fraction of a cent each, can be used freely to enclose in letters, distribute at meetings, and furnish supplies to various groups. New pests are being discovered; old ones become rampant, harmless forms become parasitic in changed environment and some old ones we hope may die out. New developments in control are constantly being made. The loose-leaf idea is flexible and new subjects can be added and old ones revised without disrupting the whole publication. Assembled sets would eventually have indices. With this end in view lists of insects and diseases and their host trees have been compiled and checked against a list of native and important introduced trees of New England and New York. The number of pests is so great that individual leaflets for each will be attained, if at all, only after many years. The present policy is to select the economically most important pests at the moment, and issue as many leaflets as the cooperators demand each year, leaving less important subjects for later issues. The practice has been to select the subjects by vote, thus maintaining the feature of a cooperative, and assign the preparation of manuscripts to individuals or agencies volunteering to prepare them.

The leaflets published in 1936 are as follows:

No. 1 The Eastern Spruce Gall Aphid *Adelges abietis* (L.)

No. 2 The Birch Leaf Skeletonizer *Buccalatrix canadensisella* Chambers.

No. 3 The European Pine Shoot Moth *Rhyacionia buoliana* Schiff.

No. 4 The Beech Scale *Cryptococcus fagi* (Baer.) Dougl.

No. 5 Tent Caterpillars *Malacosoma disstria* Hbn. and *Malacosoma americana* Fab.

No. 6 The European Spruce Sawfly *Diprion polytomum* Hartig.

No. 7 The White-Pine Weevil *Pissodes strobi* Peck

No. 8 The Sugar Maple Borer *Glycobius speciosus* Say also *Synanthedon acerni* (Sesia).

No. 9 The Elm Leaf Beetle *Galerucella xanthomelaena* (Schrank).

No. 10 Nectria Canker of Hardwoods in New England *Nectria coccinea* and other species.

The preponderance of insects in the list reflects the greater popular interest in and demand for information on them, contrasted with the no less destructive, but often less spectacular inroads of fungi.

The Cooperators

The cooperators in 1935-36 included the following: all the state foresters and conservation departments of the seven states; the agricultural experiment stations; the extension services, and state universities; the forestry schools, colleges and universities, the forestry and park associations; federal bureaus, such as Office of Forest Pathology, Bureau of Plant Industry, Division of Forest Insects, Bureau of Entomology and Plant Quarantine, Northeastern Forest Eperiment Station, and White Mountain National Forest.

The scope of this cooperative effort should be as wide as the field of forest protection in order to enlist the interest of all. Disease and insect enemies of stored timber should appeal to the lumberman and wood technologist. Injuries caused by grazing, fire, wild animals, and birds and even trespass should also find a place.

Conclusion

The project is at once a producer and a consumer cooperative. To be successful any cooperative needs whole-hearted support of all in the group. The number of organizations subscribing to the publications should be constantly widened, and with the added support and larger editions further economies in printing can be attained. The wide dissemination of forest protection information may be expected to result in increased support by the public for the organizations cooperating.

A STUDY OF NATURAL TREE REPRODUCTION IN THE BEECH-BIRCH-MAPLE-HEMLOCK TYPE

By A. F. HOUGH

Allegheny Forest Experiment Station

One of the most important silvicultural problems in the hardwood forests of the East, is to determine effective methods of building up an understory of advance growth prior to logging of even-aged stands. Without such an understory, future stands of desirable seedling reproduction will be the exception rather than the rule. A six-year record of the behavior of regeneration in a 60-year-old stand points the way to methods of timber stand improvement applicable to the beech-birch-maple-hemlock type of Pennsylvania.

IN the winter of 1927-28 the Allegheny Forest Experiment Station began a study of various methods of cutting in a 60-year-old stand of second-growth forest on the Allegheny Plateau in southeastern Warren County, Pa. This is in the beech-birch-maple-hemlock type; hemlock was little represented in this particular stand. One plot of 1 acre was reserved as a check, another was cut to a 10-inch d.b.h. diameter limit, while a third was selectively cut for sawlogs and chemical distillation wood. A study has been made of the natural regeneration present at the time of logging and established during the period of 1928 to 1933 after cutting. Detailed maps showing the location of all tree reproduction and lesser vegetation were made, and reexaminations of the 6 half-milacre quadrats on each plot were made in the spring and fall of each growing season for 6 years. This was a generally dry climatic cycle and included the drought year of 1930. The precipitation during the summer months, (June-September), was below normal for 1929, 1930, 1932, and 1933.

Germination of Seed and Survival of Current Seedlings

It was found that during the spring many seeds germinated; nearly all species present in the stand being represented by seedlings in greater or less abundance. The overstory left after cutting was 10 to 16 inches d.b.h. and was a constant source of seed supply to the forest floor below. On the check plot trees up to 29 inches d.b.h. were present. Seedbed conditions were generally favorable on the check and partially cut plots throughout the period studied.

Few of the newly germinated seedlings were able to survive until the next growing season. A critical period for such current seedlings is the summer drought, generally occurring every year from late July into August or even September and broken only by occasional thunder showers. The effect of this dry period on the water supply of these tender seedlings is accentuated by root competition from the overstory trees and lesser vegetation. In some cases direct insolation and factors such as fungi, insects, and animals cause the death of seedlings. With the approach of winter many current seedlings are nipped by frost and still others are buried beneath the heavy hardwood leaf-fall and snow, never to arise again. As a result the survivors of a particular year's crop of seedlings are very few.

Mortality of Current Reproduction by Species

Sugar maple seedlings which originated during the spring of 1928 and 1929 suffered no losses on certain quadrats and 18 per cent or less on others, prior to the winter of 1929-1930, when about 50 per

cent died. By 1933 these sugar maple seedlings of 1928 had lost 82 per cent of the original number. White ash and black cherry of the 1928 crop lost 39 and 44 per cent of the total number respectively, during the first winter (1928-1929), and mortality continued high during the following years until by 1933, 82 per cent of the white ash and 88 per cent of the black cherry were dead. These species show the same trend for the 1929 crop of seedlings with 78 and 89 per cent mortality for white ash and black cherry by the fall of 1933.

Yellow birch and black birch seedlings were not especially abundant except in 1932 when 584 germinated on the 18 half-milacre quadrats. Of these only 5 survived the summer season and only 2 were alive the following spring. The mortality of birch seedlings was practically 100 per cent on these plots, and favorable conditions for such small-rooted seedlings were absent.

Beech logged in 1927 produced many stump sprouts and root suckers, none of which established a root system of its own, all dying by the spring of 1932. Beech seedlings were rare, even on the check plot where seed trees were abundant, and all died within three years.

Mortality of Advance Growth and Seedling Sprouts

Mortality of advance reproduction or established seedlings and seedling sprouts is much less than that of current seedlings. Sugar maple reproduction, already established in 1928, lost but 42 per cent of the total in the five year period; white ash 47 per cent and black cherry 56 per cent. It was noted that advance reproduction is capable of withstanding a logging operation and, when cut off or bent down, sends up sprouts to perpetuate itself. Black cherry, sugar maple, white ash, and hop-hornbeam, (*Ostrya virginiana*), are species producing such seedling sprouts when injured. Following frost and rabbit injury, repeated sprouting of white ash and sugar maple was also noticed.

Height Growth of Current and Advance Seedlings

All species grew slowly in height beneath the canopy of the check and partially cut plots. Current seedlings of 1928 and 1929 ordinarily made poorer height growth than did established or advance seedlings. Many seedlings barely held their original height or took 2 or 3 years to grow 1/10 of a foot, while some actually became shorter due to basal bending by twigs and leaf litter, frost, rodent, fungus, and insect damage. Black cherry and hop-hornbeam seedlings made the best growth during the 5-year period after logging, reaching 3 to 7 feet in total height. Sugar maple and white ash seedlings grew very slowly and seldom reached 4 feet in height, the average being nearer 2 feet.

Height Growth of Seedling Sprouts and Stump Sprouts

Excellent height growth was shown by seedling sprouts of black cherry, hop-hornbeam, and sugar maple. The best height growth made by such reproduction was that of a multiple seedling sprout of hop-hornbeam, three stems of which reached an average height of 11 feet in 6 years; the tallest was 16.3 feet in height in 1934. Black cherry seedling sprouts created by logging injuries attained heights of 5 feet while sugar maple sprouting from the base of a cut sapling reached heights of 4 to 7 feet in 5 years.

Stump sprouts of black cherry are subject to stump rot transmission and often inferior in form, but are 13 to 24 feet tall and 1.6 to 2.5 inches d.b.h. five years after the 1927-28 logging. The tendency is for these undesirable sprouts to crowd out seedling or seedling sprout reproduction.

Factors Involved in Natural Reproduction

One of the main factors limiting the survival and growth of natural reproduction is the supply of soil moisture available during critical periods for the relatively shallow roots of any newly germinated seedlings. This lack of moisture in the upper soil layers is intensified by exposure of the site due to heavy cutting which results in less shading of the forest floor, and greater insolation and evaporation, especially during dry periods late in the summer months. Local conditions also intensify this unfavorable factor on certain sites; examples are shallow soil underlain by large rocks, and denuded soil compacted by logging and subject to washing, as in skid roads.

Another major factor inhibiting seedling establishment is competition with trees of the reserved stand and with sprout growth, blackberry, and other shrubby and herbaceous species which follow opening of the crown canopy. Heavy shade and root competition result in poor survival and slow growth of even tolerant seedlings able to endure such conditions.

Seed bed also plays a part, local areas covered with slow-rotting hemlock slash, or with dense hardwood slash, being unfavorable for seedling establishment. Old rotted hemlock logs and stumps are favorable to the germination of birch and hemlock, but survival is poor due to drying out. Hollows subject to excessive moisture for part of the season, and intermittent stream beds, are not favorable sites. Dense accumulations of hardwood leaves bury small seedlings and may hamper germination in local areas but decomposition of this leaf litter is rapid and has resulted in a good top soil condition.

Other factors reducing seedling survival are browsing by deer and rodents, frost and winter killing, fungus diseases, and insect damage.

Application of Results

Building up of an understory of advance tree reproduction in an even-aged forest is a long time process even after the stand reaches seed-bearing age and light conditions become favorable.

Seedlings starting after a partial cutting of the stand cannot be relied on to survive or grow sufficient vigor to become an important part of the succeeding crop. Chief reliance must be placed on the seedling sprouts resulting from injury to older advanced growth seedlings. The growth rate of such seedling sprouts is quite rapid. The presence of stump sprouts of still greater growth rate, which are subject to rot, and in the case of black cherry are of poor form, creates a problem of early weeding to secure a desirable stand.

In order to have established reproduction available on the ground at the time a final clear cutting is made, it is advisable to open up the crown cover by thinning or make a light individual tree selection cutting some time prior to the final logging. This favors the germination, survival, and growth of seedling reproduction. Cutting back poorly formed advance seedlings, causing them to produce the desired seedling sprouts, may be done at the time of the final clear cutting.

Subsequent weedings to favor the better species and individuals of this advance reproduction should follow within the first 10 years as a stand improvement measure. Multiple-stemmed trees of all species, especially stump sprouts of black cherry and red maple, should be discriminated against in the weeding operations.

DIRECT SEEDING IN THE LAKE STATES

By HARDY L. SHIRLEY

Lake States Forest Experiment Station

The greatly enlarged reforestation activities undertaken during the past few years by federal and state agencies have again awakened interest in the possibilities of establishing forests by sowing seed directly in the field. Since experiments with direct seeding were begun in 1926 in the Lake States and have been intensively pursued since 1930, the results of these trials may be worthy of consideration by those now engaged in the study of this problem as well as by the practitioner who is responsible for reforestation activities.

THE experiments on direct seeding carried on by the Lake States Forest Experiment Station are the direct outgrowth of studies in natural forest reproduction, designed to evaluate the efficacy of seed trees. During the eleven-year period, a total of some 130 different plots have been seeded using twenty distinct methods and eighteen species. The actual area involved comprises about 310 acres, widely scattered on the National Forests of Minnesota, Wisconsin, and Michigan.[1] Most of these plots were examined in the fall of 1936 to determine the degree of success.

In Table 1 all plots established since the study began are classified by the degree of stocking[2] existing at the end of the first season, and by the degree of stocking existing in the fall of 1936. Sixty-one per cent of the plots had a stocking of 50 per cent or better at the end of the first growing season, including those established in 1936, but after the extremely severe summer of 1936, only 15 per cent of the plots remained in this class. Had this table been prepared as of October 1, 1935, the results would have been far more encouraging.

Although most of the trials are now failures, through careful study of these experiments, a great deal has been learned about the factors which influence successful seeding. In the discussion of these, the results of specific experiments will be drawn upon for illustration without describing in detail the many tests involved.

Climate and Time of Sowing

Generally speaking, the climatic conditions prevailing throughout the Lake States are only moderately favorable for direct seeding. The first critical period is during germination. If a few weeks of favorable weather occur in the late spring, good germination may be expected. One good rain is often sufficient. One of the most successful sowings was made in the spring of 1932 on extremely dry sand soil. An inch of rain fell the same night, and only scattered showers occurred thereafter until late summer. Should the spring be too dry for germination but be followed by plentiful rains in late summer, many seedlings will come up, of which only a few are likely to survive the winter.

Fall sowing may be practiced to eliminate danger of the soil becoming too dry for germination. Fall sown seed has the

[1]The writer has drawn freely upon the results of direct seeding tests established by F. H. Eyre, R. K. LeBarron, P. O. Rudolf, F. G. Kilp, J. Kittredge, Jr., J. R. Neetzel, T. S. Gill, D. H. Isch, W. W. Intermill, and K. Pomeroy, whose work is hereby acknowledged.

[2]Complete stocking would mean one or more seedlings for each seed spot or for each 10 links of plowed furrow.

advantage of low temperature stratification over winter, which induces prompt germination during the first warm days of spring. It is particularly to be recommended for species such as white pine and white spruce which germinate irregularly without previous moist, low temperature stratification. In all the tests that have been made, fall sown seed have germinated very satisfactorily. They are, however, exposed to severe damage from birds and rodents.

Sowing early in the spring, as soon as the frost is out of the ground, is the best practice in lieu of fall sowing. If white pine, white spruce, or other species requiring stratification are used, better results may be expected from pretreated seed.

Of all the trials made, complete failure of seed to germinate has occurred only twice. These failures occurred when open sandy areas in central Wisconsin and northern Minnesota were seeded late during dry years. Poor germination has been confined mostly to white pine, white spruce, yellow birch, sugar maple, and basswood sown in spring without previous treatment.

The next critical period, from the standpoint of weather, begins immediately after germination and continues until the juvenile needles are formed. Dry weather at this time will result in heavy losses particularly if it is accompanied by high temperature. Heating of the surface soil to a temperature of 120° F. even for only an hour may result in almost complete loss of seedlings.[3] From studies of direct seeding, and also from observations in nurseries, it is the writer's opinion that high temperature of the surface soil during late spring and early summer is a more important cause of loss in the Lake States than drought. Records from the Huron National Forest show that during the summer of 1936 the temperature of the surface soil remained above 130° F. for periods as long as eight hours on the hotter days. The almost complete loss of seedlings during 1936 is attributed chiefly to excessive heat.

Drought usually occurs in mid or late summer and if excessive may cause almost complete loss of seedlings. The years 1930-1936 have been marked by a high frequency of drought. Since 1926 the most severe years have been 1930, 1933, 1934, and 1936. The most favorable year was 1935 when 20 of 24 plots sown were successful at the end of the first season. The heaviest mortality occurred in 1936 when only one out of 11 plots came through the first summer. Even seedlings of the 1932 sowing succumbed in open areas. Both high temperature and lack of rainfall combined to make the year 1936 the worst of all for direct seeding. The year 1934 was excessively dry in early spring and consequently unfavorable for germination, yet 13 out of 22 plots had 50 per cent stocking at the end of the season.

Although winters are severe in the Lake States, the ground is ordinarily covered with snow so that seedlings suffer little damage. Cases of frost heaving on heavier soils have occurred but this usually causes less damage to seedlings than to trees planted in the fall.

Table 1

STOCKING IN SEEDING EXPERIMENTS

Degree of stocking per cent	At end of first growing season: No. of plots	At end of first growing season: Total area acres	Fall 1936: No. of plots	Fall 1936: Total area acres
50-100	79	94	20	32
20- 49	30	106	34	65
0- 19	21	110	76	213
Total	130	310	130	310

[3]Shirley, Hardy L. Lethal high temperatures for conifers and the cooling effect of transpiration. Jour. Agr. Research, 53:239-258, 1936.

Summarizing weather conditions, we may say that only two years, 1930 and 1936 of the period 1926-1936, have been so severe as to cause practically complete failure of seeded areas. During these years plantations fared but little better. One year, 1935, was decidedly favorable and the others were marked by success on favorable sites, and failures on unfavorable sites. Even in 1936 fair stocking was obtained on one particularly favorable site.

Site

Except for swamps or particularly rocky sites, no area can be established to conifer forests by direct seeding, which cannot be planted successfully. This would seem to be axiomatic yet many men condemn direct seeding after trials on areas which they have been unable to plant successfully.

Two factors of site are of particular importance, soil and vegetative cover.

Soil.—The most important characteristic of soil is that it be moist near the surface during the germination period. Loam, silt, and clay soils are more likely to be moist than sandy soils. North exposures and other moist situations are favorable. Large open areas of sandy soil are likely to be unfavorable unless especially good moisture conditions prevail.

The majority of the test sowings have been made on sandy soil, where at least two seasons must elapse before the seedlings can be said to be as well established as a one-year-old plantation of the same aged trees. A good example is the 1935 sowings in the Moquah and Oconto Units of the Chequamegon and Nicolet National Forests. Three areas of roughly 5 acres each were sown on the Moquah in the spring of 1935. The spring examination in 1936 showed each to be well-stocked—80 per cent or better. During the extremely hot weather of the summer, losses were so great on all three areas that reseeding or planting is necessary. The highest degree of stocking was only 27 per cent. A similar sowing on the Oconto had over 80 per cent stocking in the spring but only 17 per cent in the fall.

Seedings on heavier soil have made a much better showing. The experimental nursery at Cass Lake is located on a silt soil. Excellent beds of one-year-old seedlings were obtained during the years of 1934 and 1935 without artificial watering. Watering was resorted to in 1936, but a portion of several beds was left unwatered. Norway pine in these beds came through almost as well as on the watered portion of the same bed. White pine was much poorer while complete loss occurred in unwatered black spruce and white spruce beds. The 1934 sowings on heavy soil on the Chippewa and Chequamegon Forests were successful and survived the 1936 heat and drought with only minor losses. Field sowings in the spring of 1935 on heavy soils on the Oconto District of the Nicolet National Forest resulted in excellent initial establishment, 96—100 per cent stocking, but during 1936 the stocking dropped to 49 per cent—still, however, significantly higher than on the sandy soils.

The most convincing demonstration of the superiority of heavy soils is the sowings made on the Peshtigo District of the Nicolet National Forest in the spring of 1936. Two acres were seeded to jack pine in scalped spots by the patrol crew immediately following the Kenney Creek fire early in June. When counted on October 13, 60 per cent of the spots had seedlings which were healthy in appearance and had made excellent growth. Practically no cover was present to provide shade for the seedlings. A second area had been burned some five or more years earlier and is now covered with sod. No shade was available. Stocking

on October 13, averaged 38 per cent. Both soils were heavy. All sowings on sandy soils in this vicinity and elsewhere in the Lake States failed completely.

Vegetation.—Perhaps the most important single factor influencing the success of direct seeding is vegetation, which, unfortunately, is also the factor many foresters seem most prone to misunderstand. The most important competitor to a newly germinated seedling ordinarily is grass, sedge, other herbs and shrubs. These must be eliminated in soil preparation. More than two-thirds of all tests tried have been on areas covered by an overstory of aspen, scrub oak, or other species. Where special care was not taken to thin the overstory, eliminate competition from the shrubby and herbaceous understory, and, if necessary, to remove hardwood leaves in spring, complete failure has resulted. With similar neglect plantations also almost invariably fail.

Shade is unquestionably a favorable factor for germination and initial survival. However, it must not be overlooked that shade also causes a reduction in the rate of growth and results in weak, spindly plants which have little resistance to competition from other vegetation, to attack by insects or fungi, or to smothering by hardwood leaves.

Because of the large expense involved in freeing seedlings from competing vegetation and bringing them up to the size of planted trees, only areas comparatively free of other vegetation can be recommended for direct seeding. In the Lake States these fall into two classes: (1) areas of sandy soil covered with a low turf of blueberry, sweet fern, and other low shrubs with or without scattered clumps of scrub oak, and (2) hardwood burns covered with grass sod and sumac or practically barren. Both require soil preparation. The former are more subject to drought, and the latter are likely to grow up to competing vegetation. Despite these facts, jack pine sown in properly prepared soil has made a very good showing on both types of areas.

Preparation of Soil

Broadcast seeding on unprepared soil has resulted in complete failure except where an excessive amount of seed, 6—8 pounds per acre, was sown. A broadcast sowing of Norway pine on the Chippewa National Forest resulted in approximately 16,000 seedlings per acre on disked soil as compared to only 2,000 on unprepared soil. One year later the same areas had 10,000 and 500 seedlings respectively. Broadcast sowing of jack pine on a plowed area on the Nicolet National Forest produced a stand of 42,000 seedlings per acre at the end of the first year with only about one fifth as many on adjacent unprepared soil. At the end of the second season, 1936, there were 2,000 and 750 seedlings respectively. Seedling height on the plowed portion varied from 2 to 5½ inches as contrasted with 1—2 inches on unprepared soil. Not only do most of the seed fail to germinate where soil preparation is inadequate, but the plants which do become established are weak and losses are very heavy. At least twelve trials of seeding without ground preparation have been made on the Chippewa, Superior, Nicolet, and Chequamegon National Forests, none of which may be called successful. *There seems to be no more certain way of wasting a large amount of seed and accomplishing nothing than to broadcast it on unprepared soil in the Lake States.*

Since jack pine frequently seeds in abundantly on recently burned areas, it might be inferred that such areas are ideal for broadcast sowing. Only a few trials on burned areas have been made. The first was a 10-acre plot located well within a 10,000 acre burn on the Chippewa National Forest. Seed was sown

broadcast in disked furrows prepared following the fire. Some seed was also scattered on unfurrowed soil. Stocking was unsatisfactory in both cases due to unfavorable weather. A trial on the Superior National Forest in 1936 showed approximately 3,000 seedlings per acre on a burned area sown to two pounds of jack pine seed per acre. Unburned land had only one-third as many seedlings.

A disk harrow is effective in exposing mineral soil on sandy areas. Disked furrows, however, have the disadvantage of being unstable immediately after opening and usually soon become overgrown with vegetation. In fact, disking frequently appears to stimulate the growth of competing vegetation. Therefore, its use should be limited to areas having an abundant supply of natural seed. The use of the spring-toothed harrow for scarification following logging resulted in an excellent stand of jack pine seedlings, which came up in late summer of 1936 after most other current seedlings and plantings had failed. Seed in this case was supplied from cones in the slash.

A number of instruments and methods were employed to prepare special spots. Some were designed to provide shade from the south, some to disguise the spots, and others to facilitate rapid preparation by hand, but all proved to be of limited usefulness. An attempt was made to prepare spots relatively inconspicuous to birds and rodents by cross-gridding the spot with spade cuts one-half inch apart. Such spots were less frequented by mice but became badly overgrown the first season.

The most satisfactory methods have been large-sized scalps which completely remove duff or sod, and plowed furrows. These are the only methods of preparation which provide freedom from competing vegetation during the first season. They have the further advantage of being easy to locate for subsequent counting or weeding. These methods have been adopted as standard in experiments established since 1932.

Species Used in Direct Seeding

The following species have been used in one or more trials of direct seeding in the Lake States: jack pine, Norway pine, white pine, ponderosa pine, Scotch pine, white spruce, Norway spruce, European larch, arbor vitae, tamarack, red oak, bur oak, basswood, white ash, black locust, butternut, sugar maple, and yellow birch. Success has been limited almost exclusively to jack pine and oaks.

Size of seed affects the success of species in two ways. The larger the seed the more sturdy the seedling when it first emerges, and consequently the less likely it is to succumb to damping-off, excessive heat or initial dryness of soil. These advantages are offset more or less by their being easily found by seed-eating birds and rodents. Seed such as white pine, which are slow to germinate without stratification, are necessarily exposed to rodents for a longer period unless artificial stratification is resorted to.

Jack pine has the advantage of a small seed, which escapes complete destruction by rodents. The seed germinates promptly and the seedling has the most rapid juvenile growth of any conifer of the Lake States. For a large scale program it has the further advantage that the serotinous cones may be collected at any time. Recent tests have indicated that loss of viability is nominal in cones on the tree up to four years of age and possibly considerably longer, so a large program never need be held up by lack of seed supply. The other conifers may be used but due to their slow juvenile growth, competing vegetation is likely to crowd them out unless one or more weedings are made. This runs the cost up considerably higher than that required for first class planting.

Red and bur oak are very valuable for direct sowing provided rodents do not destroy the seed. The seedlings are vigorous and attain good size the first year. Red oak seedlings from acorns sown in 1935 on the Nicolet National Forest came through the hot dry weather of 1936 better than any coniferous seedings or plantations of similar age. Red and bur oak sown in the fall of 1933 on heavy soil on the Chippewa National Forest had stockings of 83 and 97 per cent respectively in the fall of 1936. Where screening of oak seed spots is necessary to prevent destruction by rodents, it is important that the screens be left on during the entire first year. The oak seedling draws upon the cotyledons for nourishment throughout the first growing season. During this dependent period the tap root is developing, which provides insurance against losses due to drought the following year. If the cotyledons are destroyed even after the leaves have unfolded, the seedling is weakened and likely not to survive. Only one trial of arbor vitae, basswood, white ash, tamarack, and butternut was made and that in the spring of 1936, when practically all seed spots failed. Due to the refractory character of basswood seed, germination should not be expected the first year unless elaborate pretreatments are resorted to.

Sowing

One of the largest items of cost in field sowing is the seed. It, therefore, becomes necessary to take considerable pains in sowing in order that seed may not be wasted. Originally seed was broadcast in furrows and scalps and pressed into the soil with the foot. This proved wasteful since only about one out of ten seeds germinated. Covering with rake and hoe and using special tools to make a suitable groove for seed was tried with improved results. One of the simplest and most satisfactory methods for sowing scalped spots is to make a groove about ¼ inch deep with either the finger or a convenient-sized stick. Six to ten viable seed are drilled in this groove which should then be closed and the soil pressed firmly. This is the standard method for scalped spots at present, and appears to be identical with the method the writer saw in use in Sweden in 1935.

The most satisfactory method used for seeding plowed furrows is drilling with a standard garden seed drill pushed by hand. The implement is set to drill the seed, as opposed to sowing in hills. Commercial drills may be adjusted to seed at the proper depth, and to sow the desired quantity of seed. From a number of tests the writer has found that 4 ounces per acre of high-quality jack pine seed is enough to give satisfactory stocking provided the season is favorable—Table 2.

Table 2

EFFECT OF QUANTITY OF JACK PINE SEED SOWN ON PERCENTAGE OF AREA STOCKED AT THE END OF THE FIRST SEASON[1]

Plot 9			Plot 10			Plot 33		
Amt. sown oz. per acre	Percentage stocking	No. of seedlings per 10 links of furrow	Amt. sown oz. per acre	Percentage stocking	No. of seedlings per 10 links of furrow	Amt. sown oz. per acre	Percentage stocking	No. of seedlings per 10 links of furrow
2½	62	2.5	2½	82	3.2			
6	89	4.1	4	87	3.5	4	100	4.2
7½	94	3.3	8	88	5.9	10	100	12.3
13	90	6.0	16½	92	10.8	16	100	40.0

[1]Plots 9 and 10 are on sandy soil on the Moquah District, Chequamegon National Forest. Plot 33 is on clay soil on the Oconto District, Nicolet National Forest.

At least twice as much seed must be used in hand sowing. The drill has the further advantage of distributing the seed uniformly so that the need for thinning will be reduced to the minimum. One man can easily sow an acre per hour by means of a drill, and by working rapidly two acres can be covered in an hour. Hand sowing requires about twice as long.

Disked furrows may be sown by broadcasting the seed and making no effort to cover it. This is wasteful of seed since only a few become covered to the proper depth for germination.

Protection of Seeded Areas[4]

Mice, chipmunks, red squirrels, and seed-eating birds have all been caught in traps baited with seed. Where abundant they may destroy almost all of the seed sown within a few hours after the workmen have left. The writer visited one area only two hours after the crew had left and found fragments of seed hulls on over 50 per cent of the scalped spots.

A few mice have been recovered from areas on which poisoned bait was distributed but this seemed not to be effective in preventing destruction of seed. Dusting seed with red lead, coating them with repellent sprays (sulphonated linseed oil) and spraying the soil after sowing all proved to be only slightly beneficial.

The most effective protection was provided by covering the spots with screens made of 2- or 4-mesh galvanized hardware cloth. Screens should not be removed until the seed coat drops from the cotyledons, and may be left on until the beginning of the second season. Conical screens may be readily nested so that a man can carry 50 or more at one time. Some of these screens have been in use for 11 years and still appear to be in good condition. In no case was a spot disturbed that had been protected by such a screen.

Attempts to disguise the spots by use of grass, leaves, or sticks have been only partially successful. Large scalped spots sown immediately after preparation and covered lightly with grass and leaf litter showed some advantage over undisguised spots but were decidedly inferior to screened spots. White pine seed sown in week-old plowed furrows on the Superior National Forest, with the seeded hills camouflaged by leaves and grass, gave 72 per cent stocking at the end of the first season, as contrasted with 64 per cent for unprotected areas and 92 per cent for seed screened with hardware cloth. Similar trends were observed with Norway pine.

The most satisfactory method is to confine operations to areas where rodents are not numerous, such as recent burns and other areas providing little cover. If soil preparation is carried out two or more weeks in advance, less damage will occur. Sowing immediately following furrowing or scalping is simply inviting all rodents in the vicinity to a royal banquet. Where rodents are at all numerous spring sowing has given better results than fall sowing because the seed is not exposed so long.

Damping-off may sometimes be an important cause of loss in direct seeding. This is usually more severe on less acid hardwood soils. In some cases a light dressing of aluminum sulphate has been applied to check losses from this cause. Where seeds are sown in scalped spots this may readily be done and offers a fair degree of protection. In the tests made, losses from damping-off have not

[4]The writer is indebted to O. Austin, Jr., and C. M. Aldous of the U. S. Biological Surve· for helping with this phase of the work.

been severe except on areas shaded by slash or competing vegetation where growth is unsatisfactory in any case. Moulding over winter also causes losses where the seedlings are bent down by a mat of leaves or needles. Areas where such losses are likely to be encountered should be avoided.

Care of Seeded Areas

With adequate soil preparation, seeded areas should require no special care the first year. Weeding may be required during the second year to prevent smothering by competing vegetation. Before the beginning of the third growing season if the seed were sown in scalped spots, each spot should be visited and all but one seedling lifted. The extra seedlings obtained may be used to plant in fail spaces and for extending the reforested area. If fail spots are rescalped and weeds cleaned from the spots at this time, the seeded area may be considered as well established as a newly planted area on which the same species and age-class are used. Thereafter the same care should be given the seeded area that would be required for insuring the success of a plantation. Areas seeded in furrows usually require no weeding. Replacement of fail places with surplus seedlings from the dense spots may be done at the beginning of the third season if necessary. Some degree of thinning may be required at the end of the fifth or sixth year, but by this time the amount of thinning required will be greatly reduced.

Cost of Seeding

As the cost of preparing the soil for seeding is the same as for planting it need not be discussed. Sowing in scalped spots is less laborious than planting and is about twice as rapid. Acorns may be planted with dibbles at about the same rate as smaller seed. Screening, if required, will increase the labor cost to about that required for planting. Sowing with mechanical drills in furrows requires no skill or training once the drill is set, and can easily be done at the rate of an acre (1 1/3 miles of furrow) per hour or about eight times the speed of planting. The cost of ¼ pound of jack pine seed, enough to sow one acre, is about 75 cents. This is well below the cost of good planting stock. The big saving comes in labor which is an appreciable item. Under most favorable conditions this will reduce the cost of seeding to 1/2 or 1/3 that of planting. This saving can be made available for weeding and replacing fail spots, or for resowing the entire area if necessary.

The Place of Seeding in a Reforestation Program

At the present time seeding cannot be recommended as an alternative to planting. It is entirely unsuited to areas where the rodent population is dense, and to areas supporting dense competing vegetation. The major advantage of seeding is that a large program need not be delayed for lack of planting stock. As a supplementary method seeding may speed up a large-scale program, and if judiciously used, may help to keep costs low. However, it is not advisable to rely on it alone.

A safe procedure is always to have available sufficient planting stock to plant all seeded areas which may fail during the first season. This will make it possible to utilize the furrows or scalps which represent an important item of cost.

Summary

The major conclusions from eleven years experience in direct seeding, involving 130 different test plots and covering over 310 acres, are summarized in this paper.

Seeding of jack pine, red oak, and bur oak has been successful on sites free from aggressive competing vegetation and from seed-eating rodents, provided the first two seasons were favorable. Other species have largely failed. Most satisfactory results with jack pine have been obtained by seeding with a mechanical drill in plowed furrows, using ¼ pound of high quality seed per acre. Comparable success may be had by hand-drilling in scalped spots but is more costly in labor. Although the cost of the actual seeding operation may be only 1/3—1/2 that for planting, subsequent costs for care during the first two years and for replacing losses which are likely to be somewhat greater than in planting, tend to offset this advantage.

Resettlement Administration Planting

WITH the planting of 65 million seedlings to date, and an intensive spring drive begun to plant an additional 50 million, the reforestation work on submarginal land development projects of the R.A. is now in full swing. The trees are being planted on seriously eroded and nonproductive land.

THE USE OF LIQUID HUMATE FERTILIZERS IN FOREST NURSERIES

By S. A. WILDE

Soils Department, University of Wisconsin

The purpose of this article is to call the attention of foresters to a simple and yet highly efficient method of improving the growth of inferior nursery stock by application of liquid humate fertilizers.

"LIQUID HUMATE" is a term coined recently by nursery men for a suspension of humus obtained by treating forest litter with a complete fertilizer solution. Although this term may not be strictly scientific, it is expressive and sufficiently accurate to serve the needs of practice.

Wisconsin studies have shown that liquid humate, prepared from certain types of duff, has a remarkable stimulating effect upon the growth of forest seedlings. It has been repeatedly observed that liquid humate, applied in suitable quantities, not only increases the rate of seedling growth, but also the resistance of the stock to unfavorable environmental influences. It also has been found that liquid humates have a unique reviving effect upon stunted, weakened, chemically burned, and even mechanically injured seedlings. This reviving effect appears to be of special practical significance.

The beneficial influence of humus extracts has been observed in several large nurseries as well as in the greenhouse.

Table 1 presents data taken three months after the application of liquid humate to 2-0 seedlings of different species in the Trout Lake State Nursery and in the nursery of the Nekoosa-Edwards Paper Company.

The differences in growth, summarized in Table 1, resulted from the treatment of seedlings of average development. Where seedlings were grown on soils very deficient in nutrients, the application of liquid humates, in some instances, increased the dryweight of the seedling as much as 10 times.

Figure 1 illustrates the growth of two-year old Norway pine and Norway spruce seedlings on untreated wind-blown sand and on the same sand treated with a humus suspension, made from hemlock-hardwood duff, ammonium sulphate, ammonium phosphate, and potassium nitrate. The total mineral nutrients applied in two years amounted to an equivalent of about 60 pounds of nitrogen as ammonia, 100 pounds of phosphorus pentoxide, and 200 pounds of potash per acre. Figure 2 illustrates the reviving effect of this suspension upon three-year old Norway pine seedlings. The first application of the humate was made after the seedlings had grown for one year in pure quartz sand.

For use in nurseries the liquid humate is prepared as follows: A barrel is half filled with duff and forest litter. The required amount of mineral fertilizers is added, and the barrel is filled with water from a hose attached to the water system. If a 50-gallon barrel is used, it will hold from 40 to 45 gallons of water after the addition of duff. While the water is being added, the mixture is stirred constantly and vigorously. After standing for several hours, the mixture is stirred again to bring fine humus particles into suspension and then siphoned into watering cans and applied to the seed beds in the manner usually followed in applying liquid fertilizers. After application of the humate, the soil is thoroughly soaked

Fig. 1.—Effect of liquid humate upon the growth of 2-year-old Norway pine and Norway spruce seedlings. (O) Untreated wind-blown sand. (X) Wind-blown sand treated with three applications of suspension prepared from hardwood-hemlock duff, ammonium sulphate, ammonium phosphate, and potassium nitrate.

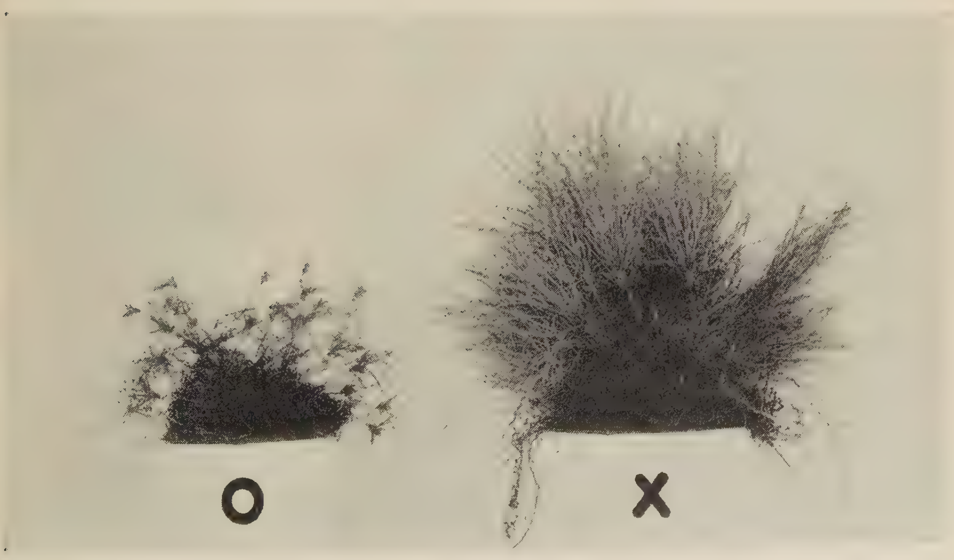

Fig. 2.—Reviving effect of liquid humate upon the growth of 3-year-old Norway pine seedlings. (O) Untreated quartz sand. (X) Quartz sand treated during the last two years of seedling growth with four applications of a humus suspension.

with water, using the hose or the overhead system. When fertilizers is applied on a large area, a battery of 12 or more barrels is employed to speed up the treatment. In order to shorten the carrying distance, the barrels are moved, as necessary, from one block of the nursery to another.

Fresh duff should be used every time the barrel is emptied. The organic residue contains a considerable amount of absorbed fertilizers, and should be stored in a pit or other convenient place, where the salts will not be lost through leaching. Such residues are utilized as an ingredient of compost or for the direct fertilization of seed beds. In the latter case the saturated duff should be thoroughly worked into the soil, since a local accumulation of concentrated material may be detrimental to seedlings or transplants.

In preparing liquid humate it is necessary to use only readily soluble, high-grade synthetic fertilizers. Fertilizers particularly adapted to this practice are ammonium sulphate, ammonium nitrate, potassium nitrate, ammonium phosphate, potassium sulphate, and 15.5-16.5-19.0 nitrophoska. The concentration of salts in liquid humate should not exceed 10,000 parts per million, which is about five pounds of total salts per 50 gallons of water.

The amount of each fertilizer to use in the preparation of liquid humate, as well as the rate of application of the suspension, depend upon the amount of nutrients present in the soil and upon other soil conditions, so it is rather difficult to give a formula which would be universally applicable. Some directions and precautions related to fertilizer practice may be found in Technical Notes No. 7, 8, 12, and 15, 1936, issued by the Wisconsin Conservation Department in cooperation with the College of Agriculture, University of Wisconsin. These reports repeatedly emphasize the fact that the application of fertilizers without sufficient knowledge of the nursery soil may result in an injurious excess of salts or may unbalance the ratio of nutrients. Consequently, the nursery may suffer a heavy loss of seedlings, or may produce unbalanced stock, lacking vigor. For these reasons, the proportions of fertilizers given later are subject to modifications to meet different conditions.

In most cases a 50-gallon oil drum and a 14-quart watering can will be found to be the most convenient vessels to use in making and applying liquid humates, and the content of salts is given in relation to these utensils.

The following fertilizers should be placed with the duff in the 50-gallon drum: 1 pound of 20 per cent ammonium sulphate, 1½ pounds of 11-48 ammonium phosphate, or "Ammo-phos", and 1½ pounds of 13-0-44 potassium nitrate, or "Potnit". The rate of application of the suspension is 3½ gallons or one 14-quart watering can per 50 square feet, or per 4 by 12 seed bed.

TABLE 1

THE EFFECT OF LIQUID HUMATES ON THE GROWTH OF NURSERY STOCK

(*Weights of average seedlings on oven-dry basis*)

Nekoosa-Edwards Nursery				Trout Lake Nursery		
Jack pine		Norway pine		Norway pine		
Untreated	Nitrophoska as humate 200 lbs/a	Untreated	Nitrophoska as humate 200 lbs/a	Untreated	Amopnos-potnit in solution 200 lbs/a	Amophos-potnit as humate 200 lbs/a
gms.	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*
2.49	4.97	1.17	2.14	0.40	0.69	1.02

The fertilizer prepared and applied in this manner corresponds to about 250 pounds of 20-20-20 fertilizers per acre, after deducting the nutrients absorbed by the organic matter. The application of salts at this rate may not improve the ratio of soil nutrients if this is out of balance, but neither will it seriously affect a balanced ratio since all the essential nutrients are added in equal proportions. Because of the low concentration of the solution used and the buffering action of humus, the danger of chemical injury is reduced to the minimum. The content of salts may be insufficient to produce satisfactory growth in some cases, and repeated application may be required. On the other hand, there is no danger of producing luxuriant, over-developed stock with a single application of this fertilizer. The treatment outlined cannot be recommended as a permanent method of soil improvement, but only as an emergency measure to be used when the condition of the stock is inferior for one reason or another.

A condition requiring some consideration is the type of organic material which should be used. Fortunately, the majority of duffs and litter are satisfactory for the purpose. The following types may be unsuitable for various reasons: (a) alkaline or nearly alkaline materials, because of the danger of encouraging root-rot diseases; (b) duffs and litter of light-demanding, pioneering species, such as jack pine, pitch pine, and scrub oaks, because of an insufficient exchange capacity and a low content of nutrients; (c) peats, mucks, and perhaps some types of raw humus, because of their lack of useful organisms, low content of nutrients, and too high exchange capacity.

No work was done with extreme types of raw humus such as occur in the Adirondack Mountains of New York state or similar regions. In the North Central region, however, experience showed that the more acid the material and the more it approaches the raw humus type, the better it is. Acid duffs, two or more inches thick, formed on well-drained heavy soils under mixed stands of northern hardwoods with hemlock, white spruce, balsam fir, or white pine proved to be most satisfactory.

When organic matter is treated with the fertilizer solution, it absorbs a large amount of nutrients. Table 2 shows the changes which a solution of fertilizer undergoes on percolating through hardwood-hemlock duff having a pH 5.3 and base exchange capacity 76 milliequivalents per 100 grams of sample.

Although the absorbed nutrients are not lost and may be fully utilized, in some cases it might be more desirable to utilize all of the nutrients immediately. This could be done by extracting the humus with a solution of a single fertilizer, such

TABLE 2

ABSORPTION OF NUTRIENTS BY HARDWOOD-HEMLOCK DUFF

Constituent	Concentration of nutrients in fertilizer solution p.p.m.	Concentration of nutrients in humate suspension p.p.m.	Loss or gain of nutrients in humate suspension per cent
Nitrates	608	1120	+ 84.2
Ammonia	2345	840	— 64.2
Total soluble nitrogen	2953	1960	— 33.6
Phosphorus	1150	580	— 49.6
Potash	5839	3263	— 44.1
Calcium	0	315	———
Magnesium	651	124	— 80.0

as potassium sulphate, or with a weak acid solution, and then using this suspension as a medium for dissolving the complete fertilizer. While this procedure is under investigation and may prove to be entirely reliable, nothing can be definitely stated as to its merits at the present time. If this method is followed, it is obvious that the amount of salts used in preparation of liquid humate must be considerably decreased.

Another problem which should be investigated is the possibility of repeated use of the organic matter. Some nursery men are using the same organic residues for three or more extractions and claim satisfactory results. If such repeated treatments are practiced, it must be realized that after the first extraction the organic matter will be nearly saturated with bases and ammonia, and, therefore, a much higher proportion of the fertilizers will come through in the solution. Consequently, this practice may lead to the application of a larger amount of fertilizer salts than is advisable.

The liquid fertilizer treatments should not be applied in the spring until the danger of frost is past. When repeated applications are needed, the last one in the fall should be made not later than six or seven weeks before the first killing frost.

Sweden Has Largest Sulphate Pulp Mill

SWEDEN'S pulp industry boasts the largest sulphate pulp mill in the world, since the completion of a new plant, the Ostrand sulphate mill, near Sundsvall. It had its formal opening last December.

ESTIMATING THE LENGTH OF TIME THAT TREES HAVE BEEN DEAD IN NORTHERN NEW ENGLAND[1]

By PERLEY SPAULDING[2]

THERE is an urgent need of a simple method for estimating how long dead trees, standing or fallen, have been dead. Tentative rules, based on intimate study of wood-rotting fungi in the decay of logging slash and of girdled trees, are here given to cover the mortality of trees for a decade prior to observation.

Two of the large perennial shelf or bracket fungi are of special significance. They are *Fomes applanatus* (Pers.) Wallr. and *F. pinicola* (Sw.) Cooke. The first grows mostly on hardwoods and occasionally on conifers, while the second grows mostly on conifers and occasionally on hardwoods. These two should be distinguished from *F. fomentarius* (Linn.) Gill., which grows on hardwoods but is not significant in indicating the time that a tree has been dead. Field characters for distinguishing these three species are as follows:

Fomes applanatus: 3 to 15 inches wide; flattened and thin on the edges; upper surface with a horny crust, gray to brown; brown under the crust; *lower surface white, turning dark where scratched.* (Fig. 1).

Fomes pinicola: 3 to 10 inches wide; flattened and rather thin; *upper surface corky,* with no distinct crust, white to gray or reddish, often (not always) granular with a varnished appearance, yellowish white within, *lower surface white, does not blacken where scratched.* (Fig. 2).

Fomes fomentarius: 2 to 5 inches wide; *shaped like a horse's hoof* and proportionally thick; upper surface with a horny crust, gray; brown within; lower surface brownish gray *with a noticeable projecting ridge around the edge.* (Fig. 3).

Single fruiting bodies of *Fomes applanatus* and *F. pinicola* may develop on dead trees 3 years after death. In the fourth year several fruits may form. In subsequent years the age of the fruiting bodies (conks, brackets, shelves, punks) can be determined by the growth layers, which are formed each year on the lower surface and which can be counted by splitting the fruiting body vertically. (Fig. 4). Hence if fruiting bodies of either of these two fungi, showing three annual growth layers, are found on a dead tree, that tree died 5 or 6 years previously, that is, 2 or 3 years before formation of the fruits plus 3 years, age of the fruit.

Besides these large perennial shelf fungi, there are numerous small annual shelf fungi, which work so much alike that they can be considered as a group without distinguishing them individually. Single scattered fruiting bodies of the annual fungi form 2 years after the tree dies. The next year more fruits form. The fourth year dozens of new ones are formed. After that, fruiting decreases or ceases entirely. All these fungi may form on living trees in fire scars and other injuries which kill patches of bark and sapwood. These, of course, should be dis-

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[1]When this paper was ready for the printer an article on the same subject but utilizing other types of field data, by David E. Hervey, entitled "A Method of Measuring the Current Mortality of a Timber Stand" appeared in JOURNAL OF FORESTRY, 34:1003 (November 1936). The two supplement each other and can very well be used in combination.

[2]Senior Pathologist, Division of Forest Pathology, Bureau of Plant Industry, Northeastern Forest Experiment Station.

Fig. 1.—*Fomes applanatus* on dead yellow birch.

Fig. 2.—*Fomes pinicola* on dead balsam fir.

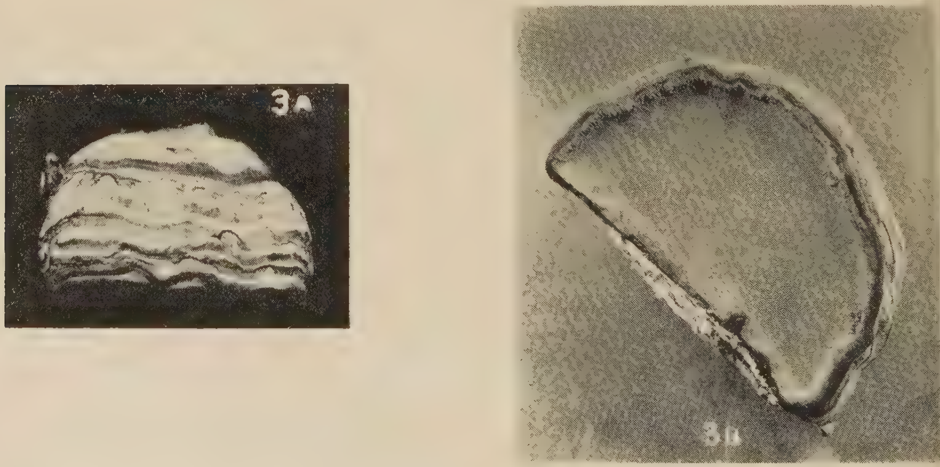

Fig. 3.—*Fomes fomentarius* fruiting bodies, showing (a) side view and (b) lower surface with ridge on edge.

Fig. 4.—Vertical section of fruiting body, showing annual growth layers.

regarded in this connection. The usual progress of deterioration in dead trees is outlined below. An allowance of 2 additional years should be made for especially moist or cool situations where decay is delayed by waterlogging; for especially warm and dry situations where decay is unusually slow; and for rot-resistant trees such as sugar maple, white ash, yellow birch, and hemlock.

Usual Progress of Deterioration of Dead Trees

First Year: Part of dead leaves still on the twigs.

Second Year: Leaves mostly fallen (e-cept balsam fir and pines). Very few small shelf fungi fruit on the bark. Sapwood rotted in small areas under the fruits.

Third Year: Leaves practically all fallen. Bark loosens on white pine and aspens. Birch twigs break sharply without splintering. Larger fungi may form small single fruits with one layer. Smaller fungi fruit by half dozens. Sapwood rotten but not punky in texture.

Fourth and Fifth Years: Sapwood is rotted and usually punky throughout. Fruiting bodies of large fungi, if present, are full-sized with 2 or 3 growth layers. (Fig. 4). Smaller fungi are plentiful. Bark is shed in many cases. Smaller branches begin to fall in the hardwoods.

Sixth to Tenth Years: Fruiting bodies of small annual fungi decrease in number. Large perennial fungi increase in number and age. By the tenth year the small fungi have disappeared and the sapwood is well rotted — punky but not falling apart. Branches of conifers begin to fall from the trunks.

THE DENBIGH DISC SCARIFIER, A NEW METHOD OF SEED TREATMENT

By J. H. STOECKELER[1] and L. C. BASKIN[1]

NURSERYMEN and horticulturists in recent years have found in the scarification of seed a successful means of hastening the germination of certain tree species and obtaining more uniform stands in nursery beds. The usual process consists of tumbling the seed in a sandpaper-lined drum revolving at 20 to 30 r.p.m. for 60 to 200 hours. Seed of some genera, however, such as *Juniperus* and *Crataegus*, have extremely hard and thick seed coats, which are very slow in wearing down by this method.

In the spring of 1936 the junior author developed a new type of scarifier which does the required work in 2 to 5 hours. The working element is a series of sandpaper-covered discs revolving at relatively high speed (from 500 to 900 r.p.m.) in a stationary metal cylinder also lined with sandpaper (Fig. 1). The cylinder is 11 inches in diameter, 24 inches long, and is made of 28-gauge galvanized iron with the ends of 1-inch pine. The upper half of the cylinder is hinged to allow removal of seed and, when required, relining the drum and discs with sandpaper. To allow dust to escape, the bottom of the cylinder has soldered in it for its whole length of 16-mesh screen, which fits over an opening 2 inches wide.

In the apparatus developed, 6 abrasive-covered discs 10½ inches in diameter and ¼ inch in thickness, held three inches apart by metal spacers, are mounted on a ¾-inch shaft. The latter is mounted on babbitt bearings and equipped with a V-belt pulley. The abrasive is designated as No. 2½ grade 30E silicon carbide sandpaper. It is obtainable in 50-yard rolls in widths ranging from 12 to 24 inches. In use, it is cut to proper sizes and held by casein glue to both sides of the revolving discs and to the entire interior of the cylinder except the screened opening in the bottom.

Tests of the scarifier with a disc speed of 750 and a load of 10 pounds of depulped seed of *Juniperus scopulorum* produced a reduction of 25 to 35 per cent in seed weight in two hours. In four hours the reduction amounted to 35 to 45 per cent, at which stage the seeds had been worn thin enough so that they could be crushed between the forefinger and thumbnail. This is the criterion of "adequate" scarification adopted at the Bessey Nursery of the U. S. Forest Service at Halsey, Neb., where scarification previous to fall sowing of *Juniperus virginiana* has largely solved the problem of erratic germination of this species.

In operating the Denbigh disc scarifier at speeds higher than 800 r.p.m., it has been observed that the seed is heated considerably by the friction developed. Since this might cause damage to the seed, it is considered safer to rotate the discs at speeds not exceeding 750 r.p.m. It has also been observed that the seed must be completely free of pulp and resin if the machine is to work at maximum efficiency. Soaking the seed in a dilute lye solution helps in obtaining resin-free seed.

From the operation of this first experimental model, the writers believe that the apparatus can be improved for large scale scarification by incorporating the following points:

[1]U. S. Forest Service, Lake States Forest Experiment Station.

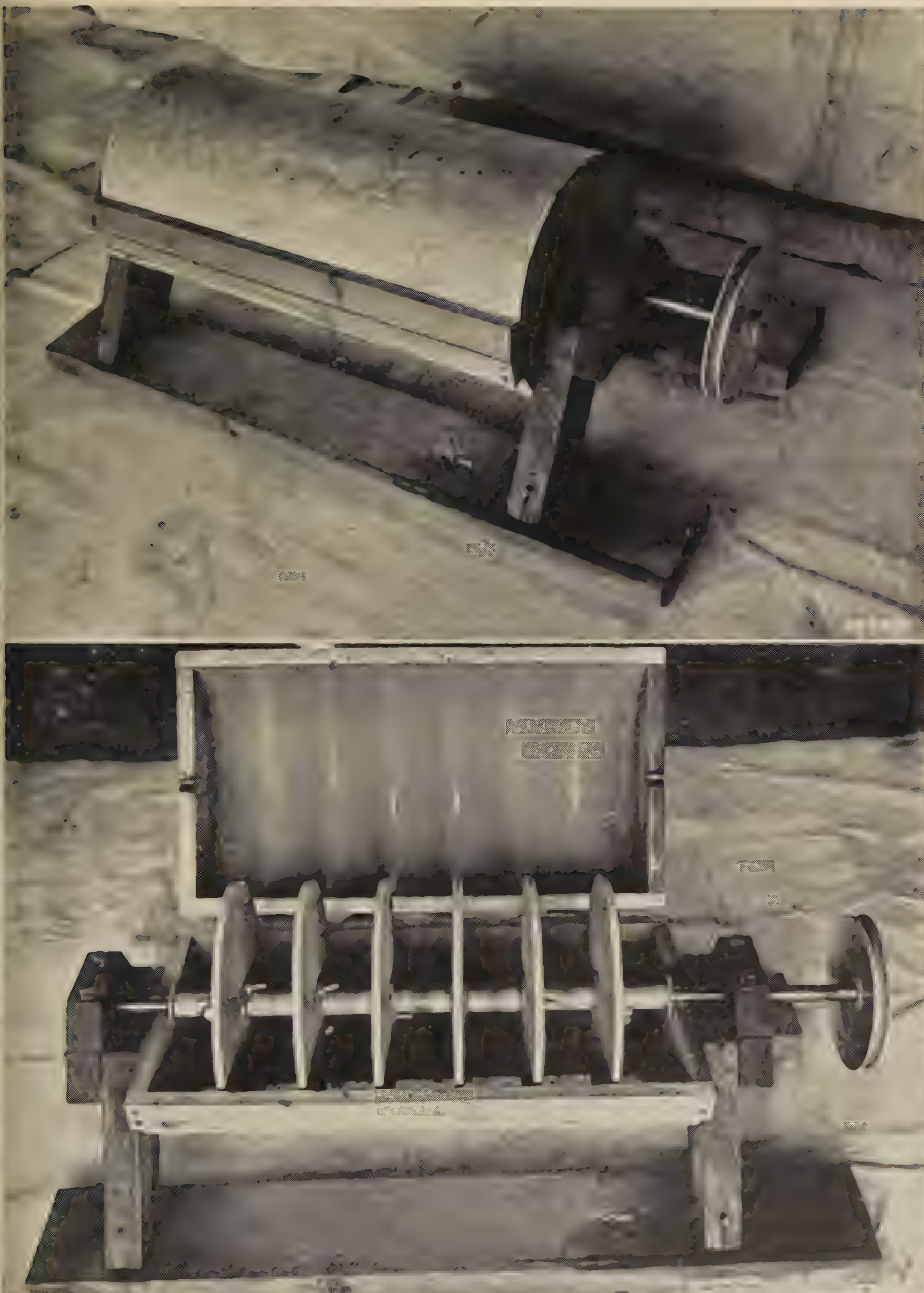

Fig. 1.—The Denbigh disc scarifier

1. Increase the diameter of the cylinder, and the number of discs.

2. Construct the revolving discs of metal.

3. Leave a 2-inch instead of a 3-inch space between the discs. Between the outer discs and the stationary ends of the cylinder leave a clearance of only 1 inch.

4. Except for the drawback of expense, thin carborundum discs might be used with advantage instead of sandpaper glued to metal or wood.

The entire problem of scarification of the seed of refractory, thick-coated species is still in an experimental stage. If the value of scarification is definitely established in the treatment of certain species, the mechanical principle of the machine described should be of practical value to nurserymen and horticulturists as well as to research workers in the field of seed dormancy.

Civilian Conservation Corps Planting

MEN of the C.C.C. have planted an average of more than one million seedlings and young trees for each working day that the corps has been in existence. Total plantings aggregate 1,035,000,000 trees from April 5, 1933 to January 1, 1937.

SOIL MOISTURE CONTENT DURING CRITICAL PERIODS IN THE REGENERATION OF PREVIOUSLY GRAZED FARM WOODLANDS

By OLIVER D. DILLER
Central States Forest Experiment Station

ONE of the most interesting observations resulting from studies of the regeneration of farm woods following continued overgrazing has been the apparent static condition of certain areas over long periods. These studies, cooperatively made by the Central States Forest Experiment Station and the Purdue University Agricultural Experiment Station (4), indicate that many woodlands which had deteriorated to the point where a complete sod cover had become established were incapable of natural recovery within a reasonable length of time. In these open areas, whenever the proper coincidence of seed crops and conditions favorable for germination occurred, tree seedlings gained a start in the spring, but during the dry summer a very high mortality often took place, and by the following season the seedlings had usually disappeared from the area.

These preliminary observations were followed up by supplementary intensive ecological studies which were carried on in a number of northern Indiana farm woods. The conclusion reached following three seasons of observations and periodic measurements (5) was that soil moisture is the principal limiting factor in the satisfactory regeneration of those grazed woodlands which have reached the advanced stages of decadence. Woodlands in which a complete sod cover has been established through the partial opening up of the stand probably suffer a greater loss of soil moisture than woodlands in any other stage in the transition from dense forest to open pasture. This has been attributed to the cumulative effect of increased transpiration and evaporation in these "open park" woods. The factors which tend to conserve moisture have been materially disturbed through the compacting of the soil surface (1), the disappearance of the protective forest litter, the elimination of the shrubby undergrowth and tree seedlings which served as an effective barrier against free wind movements, and the formation of a sod cover. On the other hand, the tremendous amount of transpiration which takes place in the dense forest has been only moderately lowered through the reduction in the number of trees.

Important problems in the management of these areas obviously hinge on the soundness of this hypothesis, and in order to secure definite quantitative data a series of soil-moisture determinations were made by the writer, with the assistance of Mace Raymond, of the Purdue Agricultural Experiment Station, during the summer of 1935. These studies were made in the oak-hickory type on a Miami silty clay loam in Grant County, Ind. Soil moisture determinations were made weekly in the A, B, and C horizons of an open grazed woods, and also in an adjacent fully stocked woods and an open pasture.

The results of these determinations are graphically presented, in terms of percentage of the moisture equivalent, in Figure 1. The tentative conclusions previously reached are rather strikingly verified in this chart. In the A horizon the percentage of the moisture equivalent in the open grazed woodland was lower than in either of the other two areas by from 1 to 4 per cent in four of the six weekly measurements. And in every case they were from 1 to 6 per cent lower than in the open pasture. In the B horizon they

were lower in five out of six instances, and again in each instance they were from 2 to 8 per cent lower than in the open pasture. The same relationship holds true in the C horizon, the grazed woodland being from 1 to 6 per cent lower than either of the other conditions. Likewise, the open grazed woodland was lower by from 1 to 8 per cent than th open pasture.

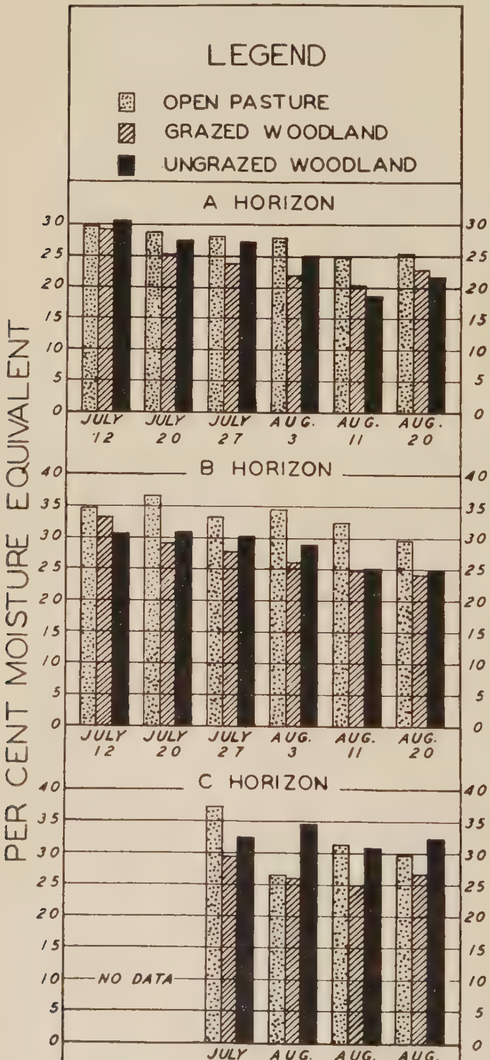

Fig. 1.—Soil-moisture conditions in a fully stocked oak-hickory woodland, open grazed woodland, and blue-grass pasture. McVicker farm, Upland, Ind., summer of 1935.

Only four rains occurred during th period of observations. The heaviest pre cipitation, amounting to 0.66 inches an 1.09 inches, occurred on July 24 an July 31, respectively. During these rain an average of 89 per cent of the tota rainfall reached the ground in the ope grazed woodland, as compared to 78 pe cent in the closed stand. Soil-moistur determinations in these two instances wer not made until three days after the rain occurred, and the influence of thes storms is not apparent in the graph. Tw somewhat lighter rains, amounting to 0.1 and 0.07 inches, occurred on July 11 an August 10, respectively. In these instance an average of 88 per cent of the tota rainfall reached the ground in the ope grazed woodland, while only 58 per cen came through the crowns in the dens forest. Since these light rains occurre just one day before the soil samples wer taken, it is possible that this account for the change in trend, as is indicate on August 11 in the A horizon.

While the differences in moisture con tent shown in the graph are not great slight decreases in soil moisture may hav significant effects as the wilting point i approached. Previous data obtained i quadrats of healthy, wilting, and drouth killed red oak seedlings indicated tha the wilting point in several grazed wood lands studied was around 22 per cent o the moisture equivalent. Although th amount of water available for plan growth cannot be determined from th moisture equivalent alone, it is consid ered to be the best single value fo interpreting the moisture properties o soils. Veihmeyer and Hendrickson (9 working on the residual soil moisture a permanent wilting of sunflower plants i 14 different soils, found that this ma vary from 26 to 58 per cent of th moisture equivalent. As shown by th accompanying diagram, the moisture con

tent in the A horizon in the grazed woodland was reduced to almost 20 per cent of the moisture equivalent on August 11. The fact that this value is below the lowest percentage obtained by Veihmeyer and Hendrickson is evidence that very critical moisture conditions have been approached, and this is very probably the reason for the high mortality of first-year tree seedlings in these "open park" woodlands during midsummer.

While it does not contribute directly to the problem under consideration, it is probably desirable to point out another relationship which appears significant in the chart. That is that the soil-moisture content in the A and B horizons in the open field was in practically every case higher than in either of the other two habitats. From these data, which were obtained during the growing season only, it would appear that the benefits of decreased run-off and evaporation (8) and increased water-holding capacity of the soil under a forest cover (1) are partially or entirely outweighed, so far as available moisture in the upper horizons is concerned, during the summer months by the tremendous amount of transpiration which takes place in the forest. According to Craib (3), Ebermayer has shown that forested areas of pine and beech contained considerably less soil moisture than open areas during all four seasons of the year. Zon (10) also points out that in level country forests tend to lower the water table and reduce the soil moisture to a greater degree than other forms of vegetation. Bates (2) has recently published data obtained from lysimeters which demonstrated that the real period of ground-water replenishment is in the winter and spring. From July to December, the lysimeters did not yield a drop of water despite a total rainfall of 18.18 inches. The apparent counter trend in the C horizon, where the moisture content is in two instances higher in the ungrazed woodland, is quite possibly due to greater water storage in the lower horizons during the dormant season. Since soil seldom freezes under forest litter and forest soil is much more porous, it is reasonable to believe that percolation occurs to a greater depth than in open areas, where no percolation is possible while the ground is frozen. Since it is generally believed that the upper horizons supply most of the water requirements of trees and that lateral movements of soil moisture in level country occurs at a very slow rate, it would appear that this concentration at the lower depths might be rather stable throughout the season.

It is fully appreciated that the results of this study, covering only one season of observations, are inconclusive, but they have served to establish a rather definite relationship between the very critical soil-moisture conditions which exist in the open grazed woodlands during the midsummer drouth periods and the repeated failure of natural regeneration in many of these areas. Further quantitative data are needed to determine the influence of forest cover on ground-water supplies in the Corn Belt region.

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THE DEVELOPMENT AND USE OF STATE FORESTS IN NEW ENGLAND IN RELATION TO WILDLIFE[1]

By R. E. TRIPPENSEE
Massachusetts State College

Wildlife is now almost universally recognized to be one of the products of a forest area. Because of the very great public interest in the wildlife resources, it is quite natural that certain conflicts of opinion have arisen concerning the proper administration of forest areas. The author shows that many of these conflicts have no basis in fact and that very often good forestry will create favorable conditions for wildlife. Specific silvicultural practices which are conducive to the maintenance of wildlife resources of a forest area are described in detail.

THE intense demand for recreational opportunities in New England makes it desirable that all public lands be used to their greatest capacity (3). While there is evidence that certain differences of opinion exist among foresters regarding the altering of silvicultural plans for favoring wildlife, the reasons for these differences are probably more apparent than real when questions under dispute are tested by actual case analyses (10).

State forests provide a remarkable opportunity for demonstrating the practicability of a correlated program of forestry and wildlife management because:

1. State forests are controlled by public agencies and can be operated for the greatest benefit to the public regardless of whether the service is the production and use of timber or wildlife.

2. If state forests are so operated they can set an example or pattern for the management of private lands in the same locality and also for state forest administration in neighboring states. All public officials who are responsible for the administration of state forests are confronted with three tasks in carrying out a well balanced forestry program. These are:

1. *Establishing Policies.*—This consists of deciding on broad general rules for the administration of the land. It outlines broad objectives without going into detail, thus allowing for differences with regard to social and economic needs, as well as differences in climate, topography, flora, and fauna on the various forests.

2. *Formulating Plans.*—A technical organization is necessary for building a program or working plan for each forest. The program will consider the possibilities and limitations of each forest in detail.

3. *Executing Plans.*—Provision should be made for the carrying out of the program including management of both timber and wildlife resources.

Policy and Program

State forests in Massachusetts were originally created for the purpose of growing trees and for public enjoyment. Wildlife is a natural forest product and adds to the enjoyment of the public for observation purposes as well as for hunting and fishing. Wildlife is dependent on the forest cover for its existence. Forest cover is also basic from the standpoint of watershed protection

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[1]Valuable suggestions and criticism in revising this manuscript have been given by Prof. H. M. Wright, School of Forestry and Conservation, University of Michigan, Ann Arbor, Mich., Neil Hosley, Harvard Forest, Petersham, Mass., Dr. P. F. English, Conn. State College, Storrs, Conn., and Dr. Paul D. Dalke, Bureau of Biological Survey, Storrs, Conn. Members of the forestry staff, Mass. State College, Amherst, including Robert P. Holdsworth, J. Harry Rich, and James D. Curtis also gave valuable assistance.

and erosion control. With these facts in mind it is safe to state that in general good wildlife management will favor good forestry. As far as can be determined there need be little or no conflict between management for wood production and management for wildlife. Conversely it is apparent that to neglect wildlife is to fail to use the land to capacity.

Programs of work for state forests should be flexible enough to fit the labor and funds available. Plans should be made which are extensive enough to utilize large numbers of men such as have been available during the past four years or for the more limited man power available during normal times.

Sustained yield for wildlife is a desirable objective of any balanced land-use policy. Such a policy however, is easier to announce that to accomplish. The accomplishment of a sustained yield of animals requires a knowledge of the breeding stock, including the sex ratio of the animals present, the number of young per clutch or litter and the number of litters each season, as well as the annual production per unit of area. The subject of census taking of animals has already been covered by a former report of the Wildlife Committee of the New England Section of the Society of American Foresters (6).

The intensity of management of both forest and wildlife will depend on the policy of the administrators as well as the amount of labor and funds available. For example, it must be decided whether an intensive degree of treatment of wildlife production should be administered over a limited area or a less intensive degree of treatment used on a more extensive area. Likewise it must be decided whether forestry for timber production should be practiced on one part of a forest and forestry for wildlife production on another. The decision should be made on the basis of which use will bring the maximum value for each acre of land managed. It appears that a combination of both timber and wildlife production will most nearly satisfy the policy of greatest return. One of the limitations of treating a limited area intensively for wildlife production is that many animals have a definite saturation point per unit of area, and therefore no matter how intense the treatment the amount of game will never exceed this limit of saturation.

Control of Hunting, Fishing, and Trapping

It is reasonable to believe that at some time in the not too distant future all state forests will have a permanent caretaker who will serve the public by supervising the legitimate uses of the area and by ministering to the needs of the land, water, and the animal inhabitants of the forest. If labor is available through C.C.C. or E.C.W. programs, suitable stations ought to be erected, as soon as convenient, on favorable sites as central control points for all public use.

Use of state lands for hunting, fishing, and trapping should be controlled by permits issued by the person in charge of the forest (9). All permits should give the credentials of the hunter, fisherman, or trapper, together with his residence, age, sex, license number, etc., and to provide for recording his daily and seasonal take of game, fish, or fur. Hunting and fishing permits should be obtained and returned daily, and fur permits at the end of the fur season.

Likewise, simple records should be kept of all types of activities regarding silvicultural treatment, timber sales, stream and pond improvement, etc., as well as totals of the kind, sexes, and amounts of the animals harvested. Also, numbers of people using each area and total number of hours spent hunting or fishing, should be summarized. Records need not be elaborate but should be thorough enough

so that management activities can be evaluated and revised on the basis of results obtained. Bookkeeping is always enlightening, and though wildlife bookkeeping is new it cannot help but bring out some new and useful information in connection with the use of public forests.

Activities Which Benefit Wildlife Primarily

There are a number of activities which may be carried on in forest areas which benefit wildlife primarily, although each may have some bearing on timber production. Activities such as pond construction, stream improvement, and planting of food species will assist in increasing supplies of animals and thus improve the quality of recreation dependent on them. Operations such as the creation of ponds may also affect timber production by helping to eliminate fire hazards as well as increasing tree growth on the part of the area where the raising of the water table brings added moisture.

Restocking of fish, birds, and mammals is also a part of any land-use program. Therefore, both the method and the degree of restocking will necessarily be a part of the policy and program of state forests. Contrary to popular opinion, it has been shown in a recent analysis of pheasants in Connecticut that heavy restocking does not necessarily mean higher populations. Before an expensive program of restocking is inaugurated, tests should be made to discover whether such measures secure the desired results.

Predator control, either on or outside of refuge areas, should be based on the known loss of animal life by predatory species and on the value of the predator as a furbearer versus the value of the animals preyed upon. These determinations can only be obtained by a careful analysis of duplicate sample areas where control versus moderate trapping or possibly no control of any kind of the carnivors is carried on. This is a research project and would take several years to complete but would probably pay good dividends by determining the exact relationships between so-called predators and game.

Furbearers are a valuable asset to any area and can be made to return good dividends if properly managed (5). The kind and number of animals to be taken and methods by which the animals will be caught are also part of the policy of a forest. Special permits for unit trapping areas seem to be a desirable way of disposing of fur resources (9). Regulated trapping and provision for the maintenance of breeding stock should become, then, a part of the program on forest areas.

Certain special uses such as camping, swimming, etc., will have to be determined in relation to their effect on wildlife and timber production. For example, picnic parties and swimming should not be allowed in refuges or on waterfowl breeding areas during the spring and early summer season.

Stream Improvement Work

New England appears to have great possibilities for improving existing conditions in trout streams. However, improvements should be made only after a careful survey by a trained aquatic biologist. Likewise all improvements should be made on the basis of the life requirements of the particular fish involved. For example, brook trout need low summer temperatures as well as gravel beds for natural spawning (2). Cover is needed for escape from predatory species and to allow the fish easy access to feeding grounds. Many stretches of stream which are at present nonproductive can be made more habitable by creating pools and cover and by forming barriers in the form of dams and deflectors. Such deflectors will protect eroding banks and

will cause the formation of sand bars behind which plant beds can form. Breeding grounds for insects may thus be increased and the stream made more productive. Devices may also be installed for speeding up the current in sluggish stretches of streams. Plantings can be made along banks to prevent soil erosion and to provide shade for lowering summer temperatures.

Refuges

The cruising radii of animals vary, and therefore the size and location of refuges should be considered with respect to the habits of such animals in mind if such refuges are to function efficiently. Refuges for deer should be from one to five thousand acres in extent, and should be in a part of the forest which contains the natural wintering grounds of these animals. Such refuges should be large enough so that the animals will not have to go beyond the refuge border during the entire year. Refuges which, because of legislative restrictions, cannot be opened to hunting after the feed has been depleted are a hazard to both the deer population and the forest cover. Opinions as to the value and management of refuges are undergoing a rapid revision at the present time. It is believed that where hunting can be regulated there is little need for refuges of any kind. With regulated hunting, only the annual surplus should be taken each year. If the area is understocked no hunting should take place until the game reestablishes itself. Where hunting is uncontrolled refuge areas will be needed for restocking the public hunting grounds surrounding each such refuge.

Very little is known about the value of refuges for ruffed grouse or small mammals such as cottontail rabbits and hares. If refuges for these animals are used at all it would seem logical to limit them from one to ten or possibly up to 50 acres, because of the limited cruising radii of these animals. During the high point in the grouse or hare cycle the "take" could well be larger than in years when the cycle is at its low ebb. During the "low" the forest should be closed entirely and the species allowed to renew itself. Timber operations where carried on according to the plan described under "Silviculture" can be allowed in refuge areas.

Silviculture as Related to Wildlife

Silviculture is the key to efficient use of forest land for both timber and wildlife production. The degree of correlation between silviculture and utilization will necessarily determine to what extent wildlife production can be accomplished (4, 10). Satisfactory cover, food, and breeding conditions are dependent on how effectively the forest cover is manipulated by the forester.

Openings are needed to provide sunlight for animal health and to maintain perennial food plants and herbaceous growth such as elderberries and clover. Therefore, from the standpoint of wildlife, not all small openings in the forest should be planted to timber trees. Small, well distributed natural openings 1/10 to two acres in size are better than larger or artificially created ones.

All intermediate cuttings and the various timber harvesting operations should be so timed and interspersed throughout the rotation and distributed over the area as to fit the needs of both wildlife and timber production.

Let us consider some of the various types of cuttings and their bearing on wildlife.

Weedings.—These are cuttings made in a young stand, still in the sapling stage, for the purpose of freeing some trees from other individuals of similar age but of undesirable form or species which are overtopping or are likely to overtop the

crop trees. Shrubs which are valuable for food and which will normally be outgrown within a short time should be spared in this operation. The removal of other species such as aspen, has the effect of creating a sprout growth which not only produces more wildlife food in the form of browse and buds, but also makes such food more available to animals such as rabbits and deer by bringing it into the feeding zone of these animals.

Liberation Cuttings.—These are cuttings made in a young stand, not past the sapling stage, for the purpose of freeing the young growth from older overtopping individuals. From the timber production viewpoint, overtopping trees may do much damage to the understory by suppression and mechanical damage. Often these trees with their extensive root systems and large crowns prevent reproduction over a large area. The elimination of such trees provides openings in the midst of a dense stand that are desirable for wildlife. Such trees may be either removed or girdled. There are advantages to wildlife for either methods of handling. Removal allows for openings and girdling helps to supply possible den trees (3). If the economic situation justifies the salvaging of such material, well and good, but some decadent and hollow trees should always be left for wildlife.

Thinnings.—These are cuttings made in an immature stand for the purpose of increasing the rate of growth of the trees that remain and the total production of the stand. Viewed from the wildlife standpoint, such an operation cannot help but provide variety of density, and with it a greater variety and quantity of herbaceous vegetation and woody advance growth as well as a greater soil activity which benefits both timber and wildlife.

In like manner other cuttings such as improvement and salvage cuttings may be justified for both timber and wildlife. However, just as sustained yield of forest products (including wildlife) and a good distribution of age classes are desirable, so is a proper distribution of cuttings desirable. The forest that has the proper distribution of age classes and is carried on systematic rotations and cutting cycles will provide opportunities for distribution of cuttings beneficial to wildlife. A certain amount of interspersion and juxtaposition is required for wildlife production. Interspersion means the intermingling of different types over a unit of area: juxtaposition indicates the degree to which such a mixture meets the needs of the animals present. For instance, given a 1,000-acre forest, the owner might strive to regulate it so that he could cut 10 acres each year starting on one side and finishing on the other side in 100 years. This might be good management from the standpoint of timber production, but it would not be good wildlife management. If, however, the same 10 acres were distributed in smaller cuttings throughout the whole area, spaced in conformity to the cruising radii of various animals, it would in no way interfere with the growth rate of the trees and would greatly benefit the wildlife.

Mast and Den Trees

A small number of trees such as beech, oak, butternut, and hickory (7), which produce food in the form of seed or mast should be left on each acre of land where they occur. While little is known about the exact amount of mast which is produced by mature trees, we may assume for the time being that two to five such trees are sufficient per acre. Trees which are to be retained for mast production should be selected on a basis of quality for timber where a choice between good and poor quality trees is available. Den trees are needed for both birds and mammals and at least one should be left on each acre.

Shrubbery and trees for shade are

needed along banks of streams or lakes for keeping water temperature low during summer as well as providing shade for aquatic life and for suitable habitats for insects which furnish the food for higher forms of stream life.

Brush disposal is another important item which has an influence on wildlife production and protection. Game birds, rabbits, and hares use brush piles for cover and protection. Brush piles can be made more useful and more durable if a large stem is placed on the top of a stump and the smaller limbs piled over this first "ridgepole" so as to allow a passageway under the brush.

Grit, which is so necessary for bird life, may be supplied where dead trees are uprooted. Overturned chestnut trees furnish an excellent example of this condition. Earth removed from dens made by woodchucks or foxes also supplied dust baths and grit for birds in forest areas. Woodchucks are not predators and should always be protected where they do not injure agricultural land.

In conclusion let me repeat and stress the fact that unless wildlife is considered as part of the returns from the land, and unless it is managed along with timber production, the area under management cannot produce to its greatest capacity (8). Those in charge of the management of state forests are not fulfilling their highest obligations to return the greatest possible interest on the money invested in them by the public unless all values, including wildlife are considered.

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BRIEFER ARTICLES AND NOTES

Shade Tree Diseases[1]

Given a field glass and asked to tell how objects appeared through it, two people unfamiliar with the use of such an instrument might give conflicting reports. Objects might seem nearer to one and farther away to the other. It would all depend upon the end of the glass through which each looked.

Much the same comparison of point of view may be made between those who investigate forest-tree diseases and shade-tree diseases. Generally speaking, both classes of pathologists are handling the same mechanism. The troubles affecting either type of tree are usually similar; the trees involved are often of the same species; the principles underlying control have no fundamental differences. Yet despite these similarities, the point of view of the forester and the shade tree expert, who carry out control measures recommended by the pathologist, too often appears to be at opposite ends of the instrument.

Gazing through his end of the field glass the forester may find himself confronted with the problem of controlling a widespread, malignant disease in timber where the margin between profitable and unprofitable production is so narrow that there is no economic basis for control save that which can be performed for a pittance. With such a problem uppermost in his mind the forester does not always realize how different the view may appear to the commercial shade tree specialist who looks through the other end of the glass. To the forester the tree expert's problem, which may involve the control of a relatively harmless fungus disfiguring the leaves of feature trees, may seem unimportant. The forester does not always keep in mind the fact that the dollar value of such ornamentals may be greater than that of many acres of forest, and that their owner may be willing to spend more to preserve their normal green foliage than the proprietor of a sizable tract of timber is able to pay to protect his forest from destruction by a dangerous disease. Thus it comes to pass that an occasional forester feels that a shade tree expert is a person who takes much money from his clients to squander on foolish and nonessential work; while an occasional shade tree expert holds with equal conviction that a forester is a person who cannot see the trees for the forest.

Today, rather than deal with specific tree diseases, I am attempting to generalize on these differences in viewpoint. In bearing with me please remember that I am not only using the field glass backward, I am also attempting to apply what I see in my own restricted field of shade-tree pathology to a broader field with which I am not as conversant as I would wish.

Pure scientific research in tree pathology is more or less equally valuable to both the forester and to the tree expert. The same premise must hold true for scientific investigations in related fields. Here the similarity ends. The practical application of information gained is not the same for the forester and the tree expert. In exceptional cases, such as in improve-

[1]Presented at the Winter Meeting, New England Section, Springfield, Mass. January 28, 1937.

ment cutting in woodland, the tree expert works with an unaltered tool, borrowed direct from the forester, only pausing from time to time to sharpen it on the landscape architect's grindstone. But such exceptions merely prove the rule. There is a broad difference in the practical application of scientific data by these two groups. More than in anything else this difference is built on the cash- and intrinsic value of the individual tree. Where the intrinsic value of the individual tree is nil or the cash value measured in but a few dollars, or even in cents, the same methods of treatment that would be warranted for a tree whose aesthetic or intrinsic worth is high, or whose historic value is held to be priceless, are not applicable.

This means that the shade tree expert is often justified in expending large sums on disease control by spraying, sanitation, fertilizing, thorough pruning, the removal of girdling roots, bracing and cabling, and a reasonable amount of cavity treatment. Let me digress here to ask that you do not think of cavity treatment as constituting the principle present activity of the tree expert. It is a highly important and technically difficult part of his task, which now represents less than 5 per cent of his total volume of business.

The necessity for controlling forest diseases with the smallest possible expenditure presents one of the most difficult problems in the entire field of applied pathology. The forester has shown rare ingenuity and resourcefulness in meeting this problem. He has largely accomplished it in the past by his skillful application of simple forms of sanitation. Now he proposes to augment sanitation with two newly forged tools, timed silvicultural procedures and disease-resistant trees.

Another fundamental difference between forestry and shade tree care arises from the fact that the tree expert must be guided by the wishes of his client. This point is particularly hard for the forester to grasp. Caprice has no place in his routine. The forester goes forward in accordance with a definite plan which he or his superior, or some other trained worker has carefully thought out. Regardless of how well the tree expert may plan, execution is subject to the whims of the client. Sometimes the client knows more about the task in hand than does the tree expert he employs, but more often the client is entirely ignorant of even the simplest principles underlying disease treatment. If the forester does not like the looks of a wolf tree, he cuts it down. He cannot understand why any reputable tree expert nurses along a shabby tottering silver maple because someone's grandfather planted it on the occasion of his 70th birthday. The tree expert knows as well as the forester what should be done; but just let him try to do it! If blister rust gets into a stand of white pine, the forester takes out the currants and gooseberries. But suppose the same forester turns tree expert. His first lady client may greet him with some such statement as: "I just love these beautiful red cedars that grow around my marvelous McIntosh apple tree, but you must cure this perfectly terrible rust." Will the tree expert eliminate an alternate host in this case? Certainly he will explain to the owner that a few strokes of an ax will do much to remedy the disease. Yet it is unlikely that his explanation will win permission to remove a single tree. The owner will probably insist that the apple and the cedars continue to grow together and that an attempt be made to control the rust by repeated sprayings.

Let us return to our discussion of values. I believe that the forester has already so well educated his public that dollars have ceased to wholly represent worth of forests. I believe that in New England at least, the comprehensive value of the trees so far exceeds their timber value

that we are now at a loss to find a satisfactory additional yardstick to supplement measurement in board feet of lumber. It would have been difficult for our forefathers to have foreseen that we would be attempting to turn back to trees the fields which they labored so industriously to clear. It is equally difficult for us to foresee how the high development of our ever-increasing regard for trees will affect the forests of tomorrow. For that reason, and you will remember that I give my ideas as the personal views of one who looks backwards through the glass, it appears to me that in the near future our present research knowledge of tree diseases will seem even less adequate than it does at present. I believe that we shall need much more research in fields of tree pathology. More than that, there will be an increased demand for the practical application of such scientific data to fight tree diseases. For the forester most of the practical application will continue along lines of sanitation and timed silviculture. In a less degree, the increased comprehensive value of his trees may force him to fight diseases with methods somewhat similar to those now used by the tree expert to check shade-tree troubles, e.g., extensive dusting from planes, the planting of soil conditioning crops prior to setting out young trees, or the application of commercial fertilizers to forest trees.

An ever increasing tide of visitors sweeps our forests annually. It brings with it new demands and new problems. Even now injury from tourists is a serious factor in some regions. With the entry of the Forest Service and its agencies into park and recreational activities a few of the trees now in the foresters' charge rightfully deserve the designation "shade trees". The responsibilities which are assumed in their care as such will include among other obligations the more intensive treatment of their diseases. Surely such changes lead toward better mutual understanding between foresters and tree experts and toward the goal for which both are striving—the preservation of a priceless public heritage.

RUSH P. MARSHALL,
Div. of Forest Pathology,
Bureau of Plant Industry.

A JOINTED POLE FOR MEASURING TREE HEIGHTS

The difficulty of measuring heights with the Abney hand level in dense coniferous stands led to the development of a series of pole sections capable of measuring heights up to 70 feet in dense or open stands of conifers or hardwoods.

Well seasoned southern white cedar was worked into octagonal pieces 1½ inches in diameter. These pieces were cut into sections 6 feet long and each section tightly fitted on its lower end with a 20-gauge brass tube 6 x 1¼ inches. A 17-gauge brass tube 12 x 1⅜ inches was tightly fitted on to 6 inches of the upper end of the section, the tube projecting 6 inches beyond the end of the section forming a socket into which the next section telescoped. The wooden shoulders of the section were sloped down to the size of the brass tubing to make handling easier. The brass tubing was indented into the wood at several points, by means of a prick punch, to prevent it from slipping or turning. The gauge of the brass tubing is important since tubing is measured by its outside diameter and the 1⅜-inch tubing of gauge 17 has a thick enough wall for a 1¼-inch tube to fit into it quite tightly. Any light weight but strong wood could be used. Spruce might be superior to cedar. Bamboo could be used if the ferrules can be tightly fitted to the bamboo. The poles were marked at foot intervals and alternate feet painted in contrasting colors, yellow and black.

A section 6 feet long was gradually tapered to a blunt, rounded point and fitted on its lower end with a 6- x 1¼-inch brass tube. This served as the end section of the jointed pole when used in dense coniferous stands. In use the end section is slipped up through the branches close to the trunk and successive 6-foot sections telescoped on as needed. An observer standing some distance away can call out when the tip of the pole is level with the tip of the tree. In taller more open stands, particularly in hardwoods, an 18-foot bamboo pole is used as an end section. This together with 8 sections 6 feet long, can be used to measure any height up to 70 feet. To measure tall hardwoods, the pole should be slipped up along the trunk of the tree to give the pole support.

To test out the speed and accuracy of the jointed pole in comparison with the Abney hand level the following stands were measured.

1. Dense, natural white birch, 27 feet high. Pole method 175 per cent faster than the Abney level method.

2. Dense, natural white pine, 32 feet high. Pole 50 per cent faster even though a 50-foot base was used with the Abney. A longer base is almost impossible in such stands.

3. Natural mixed hardwoods, 33 feet high. Pole faster although a 100-foot base was possible with the Abney due to the leafless condition of the trees.

4. Natural mixed hardwoods, 47 feet high. Pole 10 per cent faster.

5. Natural, old hemlocks, 58 feet high. Pole used to 69 feet and worked successfully and rapidly being 30 per cent more rapid than the Abney.

6. Open, natural gray birch, 32 feet high. Pole was 100 per cent faster than the Abney. After measuring by pole and Abney, the trees were cut down and measured with a tape. Averages were: pole 31.8 feet, Abney 32.8 feet, tape 31.9 feet. Abney measurements varied from —2 to +3 feet, and pole measurements from —1 to 0 compared with the tape measurement.

Hundreds of measurements have been made in very dense plantations of spruce, red and white pine, and larch varying from 10 feet to 50 feet although no comparative time records were kept. The jointed pole is extremely adaptable to all sorts of conditions. Where the stand is dense and a long pole can not be used the 6-foot sections work admirably and can be started close to the bole up through the branches from below.

The cost of making a pole of 9 sections is about $4 for materials. The weight of 8 sections and the 18-foot bamboo pole is about 17 pounds. The brass tubing is often difficult to secure in the proper sizes but it usually can be furnished by a firm manufacturing plumbing supplies.

ADVANTAGES OF THE POLE METHOD

1. Greater accuracy.

2. Greater speed, especially in stands less than 40 feet high, dense coniferous stands and hardwood stands in the leafless condition.

3. Requires less skill and is less subject to mistakes.

4. Cheapness and ease of construction.

5. Adaptability to all kinds of stands at any time of year.

DISADVANTAGES OF THE POLE METHOD

1. More laborious.

2. More bulky to carry.

3. Three men required to operate.

4. Harder to use on clean-boled trees.

The advantages of greater speed and accuracy outweigh the disadvantages of slightly greater labor and greater bulk. Two men can handle either method although three men work more advantageously with the pole than with the Abney; one man pushing up the pole

one handing the sections to the first man and one observing the top and keeping the records. The average time with the pole was from 1 to 2 minutes per tree in the different stands.

RAYMOND KIENHOLZ,
Conn. State Forest Service.

AN IMPROVED ANGLE LEVEL FOR CROWN MAPPING AND LINEAL SURVEYING

Buell[1] and Holdsworth[2] in recent notes described instruments devised for crown mapping. Foresters who occasionally do work of this nature will be interested to learn that an instrument adapted to such use is now being manufactured, and is available at a reasonable price.

This practical instrument, a modification of an ordinary engineer's angle level, embraces the features of portability and precision for measurements involving an accurate projection of a vertical line from the ground to the outer edge of the tree crown, or between two points along the ground. It was recently designed by, and may be obtained from Walter Thorburn, 2030 Ingersoll Place, Seattle, Wash.

The angle level as originally assembled was used for projecting horizontal lines, often necessary in offset work in rough country, or in projecting right angle lines slantingly along a steep slope or a series of parallel lines from measured points along a known base. This instrument as originally developed by Thorburn is admirably adapted for sample plot establishment in forest research work. Its convenient size and light weight suggested its usefulness in both lineal survey and crown mapping activities of the Central States Forest Experiment Station.

At the suggestion of the writer, Thorburn developed an angle level permitting vertical projections. In the modified angle level (Figure 1), the right angle tube has been considerably shortened to provide more light on the reflected field, and the level vial has been changed to permit vertical projections. In adding this new feature, the usefulness of the original angle level is in no way affected, for the level vial and the blank plate covering the aperture over which the level vial is placed when it is desired to project horizontal angles, are interchangeable. The front telescopic piece carrying the metal reflector can be placed in position for either horizontal or vertical projections.

Use of the angle level for crown map-

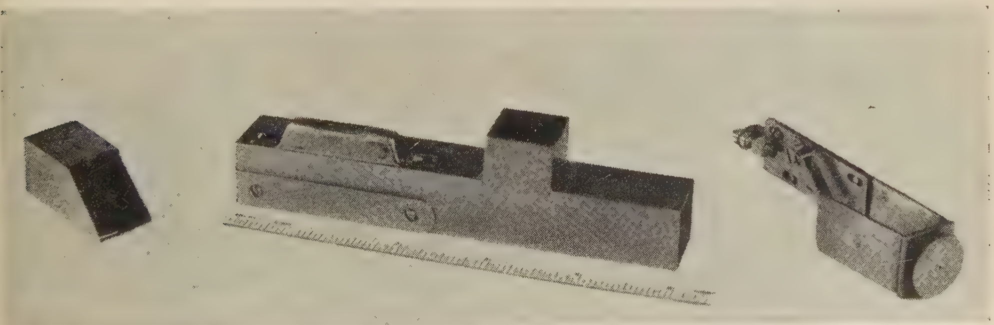

Fig. 1.—The Thorburn modified angle level, showing construction. About one-half actual size.

[1]Buell, J. H. Crown mapping simplified by the use of an Abney level and a mirror. Jour. For. 34: 77-78.

[2]Holdsworth, R. P., J. D. Curtis, and D. McCleary. A reflecting crown meter, Jour. For. 34: 528-530.

ping requires no special explanation for those familiar with the usual procedure. It is important that the instrument be held level when the image of the crown is centered with the cross bar in the angle mirror. The projection of the tree crown border thus established may be marked, using a 30-inch surveying pin, and measured and platted when a sufficient number of points have been secured.

The instrument is small and light, and is capable of performing a surprising variety of field tasks encountered by a forester. It is supplied in a convenient leather case which can be carried on the belt. In appearance it is much like the ordinary hand level without the vertical arc, although there are other models developed by Thorburn which embody this additional feature.

JOHN G. KUENZEL,
Central States Forest Experiment Station.

Logging Storm-Thrown Timber

On September 4, 1935, the west coast of Florida was hit by a tropical storm which partially demolished the sawmill town of Foley, home of the Brooks-Scanlon Corporation, and uprooted forty million feet of pine timber on the company's holdings. The problem was how to salvage this amount of timber before the sapwood became discolored.

The logging normally is done by steam skidders and railroad, but this emergency called for selective logging over a very large area where steam methods would be too slow and expensive.

The tract is very favorably located in regard to transportation, being crossed north and south and east and west by both main highways and railroads.

The mill repair work was rushed and in two weeks was ready to run again on a double shift, cutting seven million a month.

In the meantime, the logging department filled all available pond and skid space with logs from existing woods spurs. The areas suitable to truck transportation were contracted to loggers having their own equipment. An average of 150,000 board feet per day was logged in this manner. In the swamps and rougher areas the company did their own logging. Six "Caterpillar Diesel 50" tractors with skidding wenches were purchased; the company had two at the time, thus making eight in all. Four 30-ton log wagons with caterpillar tracks and one 10-ton Fairlead arch and ten Ford and Chevrolet dual-wheel log trucks with dual-wheel trailers completed the new equipment.

Logging spurs were built one-half to one mile apart, and steam skidders pulled what could be reached—800 feet being the limit—and the "Cats" brought in the rest, using the wagons and arch on the longer hauls. The steam skidders were used only to speed up the operation and were not as satisfactory as in clean cutting because of the lines cutting the sides of standing trees, logs jacking or getting hung behind standing trees, and the constant fire risk. Also, the necessity of covering all the ground with the lines for only 40 per cent of the timber ran the cost much higher. The "Cats" were able to wind among the standing timber and get the down timber nearly as cheaply as if clean cut. In cutting the timber all tops and limbs were removed from the base of standing trees to help keep bugs out and lower the fire risk.

After the first two months the truck logging became too expensive, due to distance, so a loading spur was placed from a main line railroad thirty miles from the mill and all trucks brought their loads to this spur, where the logs were loaded on cars by locomotive crane and a 30-car train of 5,000 feet to the car went to the mill each day.

When all this equipment was organized

the logs came to the mill faster than they could be cut, so a 16-acre storage pond was built at the mill. This held about two million feet; an additional pond at a nearby mill held another million; and a roadside ditch about four miles long beside a railroad took another six hundred thousand feet. These logs in water were left until last and were bright and clear when sawed.

The salvage operation was favored with a long, cold, dry winter, which kept the logs from staining and insects from working. This intense program of salvaging the storm timber made it possible to save what would have been a total loss if allowed to lie on the ground for a year.

The first of May 1936 found the woods cleared of storm timber and ready to resume normal operations.

M. W. Hitchcock,
Brooks-Scanlon Corporation.

A Folding Cruiser Stick

For some few years the writer has felt that a "pocket" cruiser stick would be a handy item of the forester's equipment.

Since there was no folding rule on the market which would measure height or diameter, a spring joint rule without graduations similar to Lufkin No. 524 was obtained. The full length of the unfolded rule is 48 inches and when folded, 6 inches. Biltmore graduations were placed in one side of the rule with a dull chisel and steel die and inked in. The rule was then varnished lightly with a clear waterproof varnish.

An hypsometer, reading heights directly in five-foot intervals for distances of 50 and 100 feet from the tree, was placed on the other side of the rule, separate scales being used for each distance. To determine the height, the top of the stick is held at the top of the tree or height wanted and the "unknown" line cuts the ground or stump height. Held in this manner, the folded portion of the rule acts as a pendulum when the rule is grasped lightly between the thumb and first finger and held upright.

So far as the Biltmore scale is concerned the limits of error and use are well known and accepted. The hypsometer has proved satisfactory where accurate measurements are not necessary. Compared with actual measurements on felled trees, the errors are as follows: for heights from 0-70 feet, the difference is negligible; for heights from 70-100 feet, the differences are from 2-3 feet. The reason for the larger error for tall trees is that the rule is too flexible when nearly fully extended. However, by using care the error can, for all practical purposes, be eliminated.

The total cost is 39 cents plus a few hours' time.

Howard A. Miller,
St. Charles, Ark.

A Cubic-Foot Volume Alignment Chart for Western Larch[1]

The construction of a cubic-foot volume table for western larch (*Larix occidentalis*) was required by the Forest Survey, now being conducted in the Northern Rocky Mountain region, before satisfactory growth predictions could be made for species in the larch—Douglas fir type. Confidence could not be placed in available tables without extensive application studies.

The cubic-foot volume tables available for western larch consist of a local table

[1]Credit is due the U. S. Forest Service, Washington, D. C., for advice and assistance in the statistical work involved in the construction of this chart.

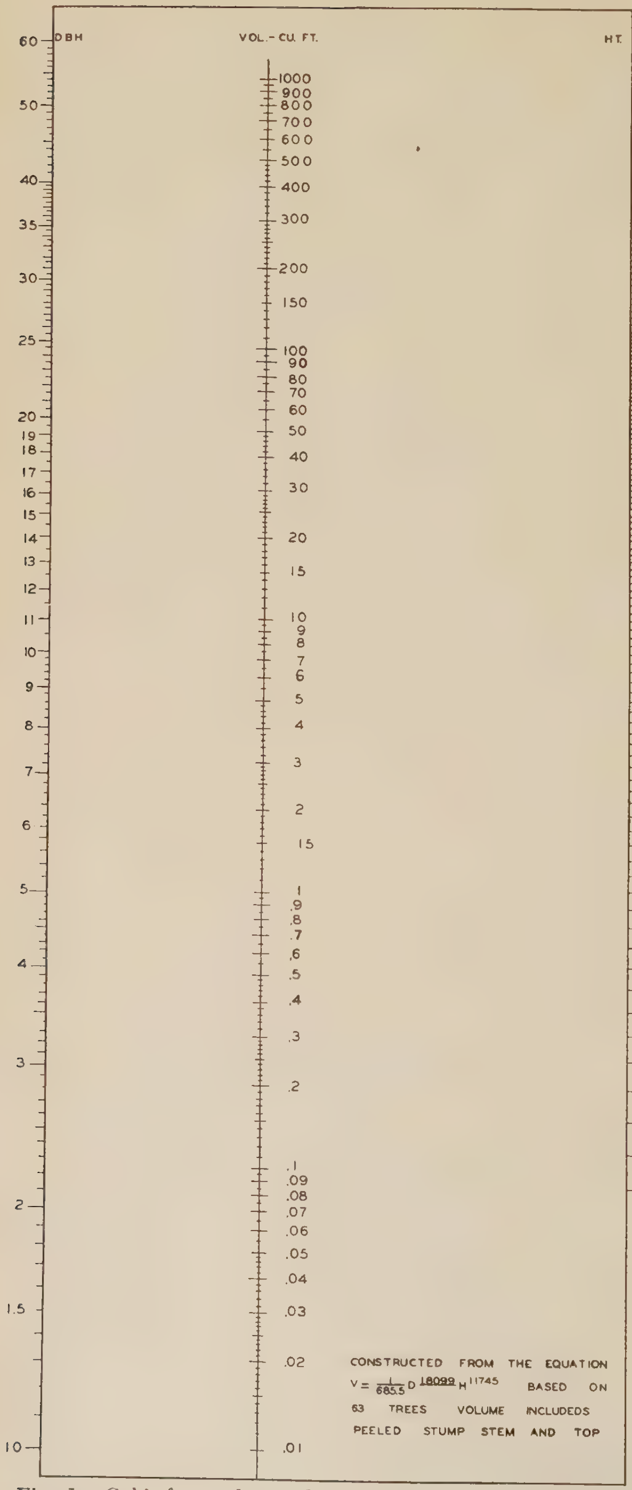

Fig. 1.—Cubic-foot volume alinement chart for western larch.

made by Margolin in 1907, for Flathead County, and a table appearing in U. S. Department of Agriculture technical bulletin No. 323, based on trees from the white pine type. The application studies and adjustments that would be necessary before either of these tables could be used with confidence of an accuracy commensurate with Forest Survey practice would require as much work as building a new volume table.

Therefore, a cubic-foot volume table applicable to the range of the larch—Douglas fir type and all of the size classes likely to be measured, was constructed following the method of Schumacher and Hall.[2] Basic data for this table consist of stem analysis made for 63 trees selected at random from logging operations, from cut trees along road and trail right-of-ways, and from trees cut from plots established during the larch—Douglas fir yield study. Size classes range from 5 inches to 32 inches d.b.h., and from 50 feet to 150 feet tall. This volume table is not applicable for local use, but will apply over the average range of the larch—Douglas fir type within the tabulated errors of estimate.

The alinement chart (Fig. 1), is a graphical

[2]Logarithmic expression of timber-tree volume. Jour. Agric. Res. 47:719-834. 1933.

expression of this volume table from which volumes can be read, diameters to nearest tenth of an inch and heights to nearest foot. The chart form of volume table is presented here instead of the tabular form because adequate tables would be very large and each user can easily read the values from the chart and build a table that suits his particular needs.

The standard error of the average for this volume table is well within the usual errors of estimate for volume tables. This is shown by comparison with the tabulated errors of estimates for nine other species listed on page 723 of the above reference. The standard error of the average is ± 1.76 per cent. Actual volume is 0.08 per cent below volume estimated from the alinement chart.

Volumes for trees larger than 60 inches d.b.h. and 200 feet tall can be computed from the volume equation:

$$V = \frac{1}{685.5} D^{1.8099} H^{1.1745}$$ when V= cubic foot volume, D = daimeter breast height, in inches, and H = total height in feet.

The formula as stated above, is more easily solved in logarithmic form as follows:

Logarithm cubic volume = [1.8099 × log. d.b.h.] + [1.1745 × log. height] — [log. 685.5].

For example, to find the cubic volume of a tree 17.0 inches in d.b.h. and 124 feet tall:

Log. V = [1.8099 × log. 17.0] + [1.1745 × log. 124] — [log. 685.5].

(1) log. 17.0 = 1.2304
(2) log. 124 = 2.0934
(3) log. 685.5 = 2.8360
(4) 1.8099 × log. 17.0 = 2.2269
(5) 1.1745 × log. 124 = 2.4587
(6) log. V = 2.22690 + 2.45870 — 2.8360 = 1.8496
(7) Volume = antilog. 1.8496 = 71 cubic feet

The logarithmic expression of the above equation is that for a straight line of the familiar form

$$y = ax + b.$$

This linear relation in logarithms of volume to diameter and height makes graphical extension of the volume table easy to do as follows: (1) using double logarithmic graph paper graduate the ordinate in volume units and the abscissa in d.b.h. units; (2) from the existing volume table or alinement chart read volumes of several trees having different diameters but the same height; (3) plot these values and with a straight edge draw a line through them extending it to the diameter desired; (4) the volume can now be read directly from the constructed curve. Extensive extrapolation, however, is not recommended due to possible graphical errors and the uncertainty of using values that depart too far from the basic data.

L. J. Cummings,
Northern Rocky Mountain Forest Experiment Station.

REVIEWS

From Forest to Furniture. The Romance of Wood. By Malcolm H. Sherwood. *284 pp. Illus. W. W. Norton & Co., Inc. New York. 1936. Price $3.*

Mr. Sherwood's treatment of his subject is rather unique. The book's freedom from technical language and tiresome statistics is refreshing, and the layman with no mental gymnastics whatever can get the gist of and absorb every word of its two hundred and eight-odd pages. The title, however, is misleading, for the reader naturally would expect the text to tell something about the various steps in the manufacture of furniture and discuss the suitability of various woods to the requirements of this industry. In reality the whole book is devoted to the figure of wood and almost entirely from the veneer standpoint.

"From Forest to Furniture" is so full of human interest that it reads like a novel, but the author's effort to present his subject in this popular, readable style has sometimes been at the expense of accuracy of statement. For instance, on p. 18 he states that the drain on stocks of walnut lumber during the World War was terrific, that "door-yard trees became as famous as taxicabs that saved Paris." At no time was there any real scarcity of stocks of walnut lumber for war needs, and owners of valuable shade trees were not encouraged to sell them.

The author's plan of the book in making it a tour around the world adds to its interest, but there are some drawbacks to this method of treatment. Mahogany is discussed under African mahogany, Circassian walnut is discussed under black walnut of the United States, and rosewood and ebony, although occurring in various parts of the tropical world, are discussed under countries where they are not necessarily of first importance.

One might question why the author does not include elm along with ash, birch, maple, and other woods of the United States. It is used in larger quantities than ash for furniture. Another more serious omission is that of the Philippine woods, chiefly tanguile and red lauan, commonly sold as "Philippine mahogany". These are important furniture woods not only in the United States but also in other countries, and I can think of no reason why they should not have been included.

This book constitutes a very valuable addition to available information on cabinet woods, and for the most part the statements seem to be accurate. The table of contents data on the 60 woods discussed, given in the back of the book with the scientific names, is a valuable addition. A few errors are noted on page 267. *Lovea* should be *Lovoa*. The author gives Benin as the common name for this wood, which name is derived from the port from which the wood is shipped. This is not a distinguishing name, however, as other woods such as mahogany from this port have been called by the same name. Lovoa and tiger wood are more appropriate, and so far as I am informed are the common names in use for this wood. *Liquidamber* should be *Liquidambar*. *Diospyros* is given as the generic name for Macassar ebony. According to authoritative information the identity of this wood is unknown, and it

seems improbable that it is a species of *Diospyros*, as are the true ebonies.

In his list of references the author gives "A Manual of the Timbers of the World"—Alexander L. Howard, 1920. This reference should give the year 1934, which is the latest edition.

A valuable addition to the book would have been a series of colored plates showing the various types of figure found in the different woods discussed. No doubt the author is well aware of this fact, and perhaps the excessive cost or some other equally good reason was the cause of its omission.

R. K. HELPHENSTINE, JR.,
U. S. Forest Service.

The Colorado Forester, Forest Service Edition. *96 pp., Illus. Pub. by the Forestry Club of the Department of Forestry, Colorado State College, Fort Collins, Colo. 1936.*

Dedicated to Ferdinand A. Silcox, and through him to the U. S. Forest Service, this forest school annual differs from most such publications. After a brief photographic introduction to the *Forester* staff and to the faculty, the booklet dispenses with scholastic personalities for 62 pages and devotes that space to articles by the Chief of the Forest Service and by regional officers.

"Present and future problems" of the Service and of each forest region are discussed. The regional men, not neglecting economic and social problems, dwell as a group more upon administration and the coordination of the various land uses.

Small half-tone cuts of the authors and of scenery typical of the regions are well placed throughout the text. The last quarter of the booklet deals with the Colorado Forest School, the Forestry Club, Alumni News, and the class rosters.

For the undergraduate student, at this and at other schools, and for the practitioner these brief but comprehensive articles should serve to deepen the appreciation of problems arising from forest land use in the United States.

ALBERT G. HALL,
U. S. Forest Service.

Oregon's Timber Taxation Problems and Recommendations toward their Solution. By Chas. V. Galloway, Earl B. Day, R. D. Moore, Thornton T. Munger, and Aubrey R. Watzek, Special Committee on Timber Taxation Appointed by the Governor. *40 pp. Salem, Oregon. 1937.*

This report, submitted to the Governor of Oregon for consideration by him and by the Legislative Assembly, describes the existing tax situation as it affects forest lands in Oregon, and proposes remedies. Its authoritative character in the taxation field is guaranteed by the fact that the chairman of the committee also heads the Oregon State Tax Commission, and is well-known as an able tax administrator.

After summarizing briefly the status of land ownership and extent of forest lands, there is a passing comment (p. 7) on the existing "reforestation" law, a special forest tax law applicable to cut-over or fire-denuded lands. The committee regards this law, which provides for a specific annual tax on land at fixed rates and for a yield tax in lieu of property taxes on the timber, as basically sound. This judgment seems inconsistent with the strong preference expressed later for the ad valorem property tax and is otherwise open to question.

The report is concerned chiefly with the problem of taxation as it relates to mature timber properties. It points out the import of this problem in Oregon and how it is affected by inequalities in rural tax levies. Earlier timber taxation proposals are reviewed. The reasons given

for the failure to enact the yield tax measure of 1933 and the deferred timber tax proposal of 1935 are illuminating.

The conclusions presented are highly significant. After giving due place to certain other problems which affect timberland management, they go right to the fundamentals of taxation as influenced by organization of local government and administration of the property tax. The keynote, like the tax reform program recommended by the Forest Service, is to correct rather than abandon the property tax. An unfortunate implication (p. 15) that the adjusted property tax, deferred timber tax and differential timber tax plans are substitutes for, rather than modifications of, the property tax, was perhaps not intended. The particular defect in the property tax which these plans would correct is not constructively dealt with by the committee, possibly because it may seem relatively unimportant at this time.

The principal recommendations are: (1) reorganization of local government for greater efficiency, involving particularly consolidation of small rural school districts under existing law; (2) assessment of timberlands by the State Tax Commission; and (3) state acquisition and disposition of tax foreclosed lands. These proposals are formulated in concrete and workable form. They should appeal to all intelligent citizens of Oregon who want sound improvements in government.

An appendix is attached, presenting pertinent statistics in convenient form. The estimated carrying charges in Table 5 do not include costs of administration and allowances for insurance or risk, and to this extent would appear to overstate the importance of taxes relative to total carrying charges.

The effectiveness of this report is enhanced by its clear and vigorous English. A rhetorician might carp at such an expression as "local assets now tightly frozen in soured tax delinquency", (p. 20). This reviewer regards no metaphor too mixed for the purpose of describing the present status of tax delinquent lands in many states.

This document represents a landmark in reports of state forest taxation committees in that special concessions to owners who promise to practice forestry, so alluring but so universally futile, are passed by in favor of real and substantial progress. Since the forestry profession is strongly represented on the committee, it is to be hoped that this publication may mark the beginning of an era during which foresters and friends of forestry will turn their eyes resolutely away from that glittering mirage, the forest tax panacea.

R. Clifford Hall,
U. S. Forest Service.

Methoden der experimentellen Untersuchung mykotropher Pflanzen. By Elias Melin. (*Abderhalden's Handbuch der Biol. Arbeitsmethoden. 11:1015-1108. 23 fig.*) *Urban & Schwarzenberg, Berlin and Vienna. 1936.*

This is a survey of the experimental methods used hitherto for investigating mycorrhizal relationships. It is written primarily for students of mycorrhizae and it will be of unusual value to them. It describes chiefly the classical pure culture techniques. Practically nothing had been published on methods suitable for nursery and plantation experimentation at the time the paper went to press. A list is also included of 31 Basidiomycetes which Melin accepts as having been experimentally established as mycorrhiza-producing fungi with trees or with "saprophytic" orchids. A much more extensive list is provided of fungi which are suspected of forming mycorrhizae.

A. B. Hatch,
University of Idaho.

Hill's Book of Evergreens. By L. L. Kumlien. *304 pp. Illus. D. Hill Nursery Co., Dundee, Illinois. 1936. Price $3.50.*

Frankly, this book will appeal less to the forester than to the commercial nurseryman or landscape architect. However, no one whose work is with and among trees can read it without benefit and enjoyment.

According to its preface, the book was written in an attempt "to answer the thousands of questions which people want to know about evergreens." The material contained in it is original only in arrangement, as the author freely acknowledges. He explains that it is primarily "designed to meet the needs of persons not interested in the botanical or scientific study of evergreens."

The volume is in four parts, as follows: I. Evergreens in geology, folklore, history, and poetry; II. Seed collecting, propagation, culture, and diseases; III. Uses of evergreens, foundation planting, outdoor living rooms, and hedges; IV. Descriptions of varieties.

As one would suppose from these headings, the author is concerned mainly with evergreens as they contribute to beautification of the landscape. He writes—most entertainingly—of trees as individuals and small groups. Brief but informative chapters on propagation, care and cultivation, planting, soil requirements, fertilizers, watering, and pruning are included; in fact, the book contains practically all the miscellaneous details involved in the nursery growing of trees. The section on the use of evergreens in landscape planting is excellent.

Considerable of the information will probably be new to the average forester; for example, that commercial nurserymen of the United States stock 24 genera of evergreens, 130 species, and 370 varieties! That the well known eastern (northern) white pine has nine recognized and propagated varieties. That the horticultural variations of Norway spruce run into hundreds, of which the author lists fifty.

As it is a common experience for the forester, whether publicly or privately employed, to be called upon as a consultant in civic improvement works, this volume can be recommended as a handy reference.

The book has a few defects which, though not serious, should be mentioned. It recommends, somewhat too obviously, the products of the firm publishing it; as it purports to be more than just a house organ, this feature is objectionable. On page 192 the author states: "An acre of Christmas trees in five to seven years time, properly managed, should net a profit of $3,000, and with practically no work, except the original small cost of planting the trees." If that were true, one wonders why not plant a hundred acres, or a thousand, and become a millionaire almost over night?

The numerous illustrations are well selected, though a few of the color plates are not well reproduced. A bibliography, chronologically arranged, is available for further reference. The index has been carefully made.

Henry E. Clepper,
U. S. Forest Service.

A Survey of Research in Forest Economics. By the Subcommittee on Scope and Status of Research in Forest Economics, Social Science Research Council. *S. S. R. C. Bull. 24. 52 pp. Published by the Council. New York. 1936.*

This is one of the series of reports prepared under the direction of the Social Science Research Council's Committee on Social and Economic Research in Agriculture. It is the second report dealing with forest economics to be sponsored by

that committee, the first being the report on "Education in Forest Economics" which appeared in the JOURNAL OF FORESTRY for February 1935. The Committee on Social and Economic Research in Agriculture has during the past two years turned a major part of its attention to exploring the situation as to economic studies in forestry, and to considering ways in which development of personnel and materials in this field might be stimulated. Procedure has thus far followed somewhat the general pattern of the earlier work on research in agricultural economics.

In that program the committee first assembled a report on the work under way and some information on the training and general qualifications of those engaged in research in this field. This was later followed by a series of reports, some twenty in number, outlining projects and possible research procedure in various subfields of agricultural economics.

The report here reviewed is an attempt to present in brief form the nature of the research in forest economics now under way and to develop a tentative classification of the various types of study. The classification adopted is as follows:

1. Inventory of the forest resources.
2. Forest land classification.
3. Forest production.
4. Manufacture of forest products.
5. Marketing and distribution of forest products.
6. Consumption of forest products.
7. Prices of forest products.
8. Forest and forest industry finance.
9. Public finance in relation to forest enterprises.
10. Public policies in relation to forest enterprises.
11. Social aspects of forest enterprises.
12. Interrelation between forestry and other enterprises.

The projects now under way are then discussed under these headings. In these subdivisions, however, the committee has gone somewhat further than a mere inventory of current projects. It has in most cases given a brief discussion of the nature of the work regarded as characteristic of the particular subfield, and in addition has listed types of studies which might be developed. Considerable work has been done in assembling and classifying information concerning the researches now under way, and the beginning made in outlining types of studies needed is a significant forward step which should be carried further.

In its statement of conclusions and recommendations the committee points out that much of the work to date has been in the collection of primary data, and that these have been subjected to a minimum of analysis. This is true, but such assembling of primary data is, of course, a necessary preliminary to more adequate analytical procedure. There still appears to be need for some small continuing committee, probably within the Forest Service, which could study the adequacy of the basic data arising, the coordination and efficiency in assembling them, and the points where significant gaps need to be filled. For many of the types of basic data assembled in the Forest Service there appears to be some lack of continuity and serial development. This, while no doubt in considerable measure a result of the nature of the industry, presents certain problems for those who seek to deal with the data in an analytical way. Possibly such a committee as that indicated above, a sort of little Central Statistical Board for Forestry, might be able, over a period of time, to round out and standardize the basic data in such a way as to further the development of analytical work in forest economics.

The report emphasizes the need for more research in the nature and measurement of the social values and relationships of forests. This is a problem which has been dealt with in very loose terms

and a more scientific approach to it would be a distinctly forward-looking step. The committee also emphasizes the need for expansion of the present research program of the federal government in the field of forest economics. Here, as in the sister field of agricultural economics, marked progress will be conditioned somewhat on the number of trained workers available. The economic problems in forestry are as intricate as those in other fields, and require as good economic training if they are to be dealt with effectively. Thus far the number of students training specifically in the combined fields of forestry and economics has been very limited.

The committee's report represents a step forward in the field of forest economics which will no doubt suggest and stimulate further development of this field of research.

M. R. BENEDICT,
University of California.

Baum und Wald. (Tree and Forest). By Ludwig Jost. *vi + 149 pp. Illus. Julius Springer, Berlin. 1936. Price RM 4.80.*

This is one of a popular science series. In the main, it deals with plant morphology and plant physiology as applied to trees. The title would lead the reader to expect something like an even division of the subject matter between trees as individual plants and trees as communities of living organisms. The first 106 pages are given to description of the form of the tree, taking typical conifers like spruce and typical broadleaf species like beech, elm, and maple as examples, with detailed descriptions of the form, growth, and functions of the various parts such as stem, roots, twigs, buds, and flowers.

Following this is a 27-page description of the virgin forest at Schattawa in Bohemia (50 hectares, or approximately 123 acres). Presumably this serves as an example of trees as living communities, subject only to the interplay of physical, biological, and chemical forces. The author takes too much of his space in describing the freakish (stiltlike) form of development of spruce caused by germination and growth on the trunks of fallen trees. Incidentally, he reports that this forest is losing its virgin (*Urwald*) character through the browsing of deer which congregate on the area.

Chapter 8 gives a brief view of managed forests, with an explanation of the two main systems of management—clear cutting and selection. As might be expected, Jost has no kind words for clear cutting.

Very neatly, in the conclusion, the author takes the old saying, "Many people can't see the woods for the trees," and reverses it by saying, "There are many who really see the woods, but know nothing at all of the trees of which it consists." To awaken interest in the forest, its care and protection, through knowledge of the tree is the announced purpose of this little book. If you read German and need a brief summary of the morphology and physiology of trees it is to be recommended.

C. F. EVANS,
U. S. Forest Service.